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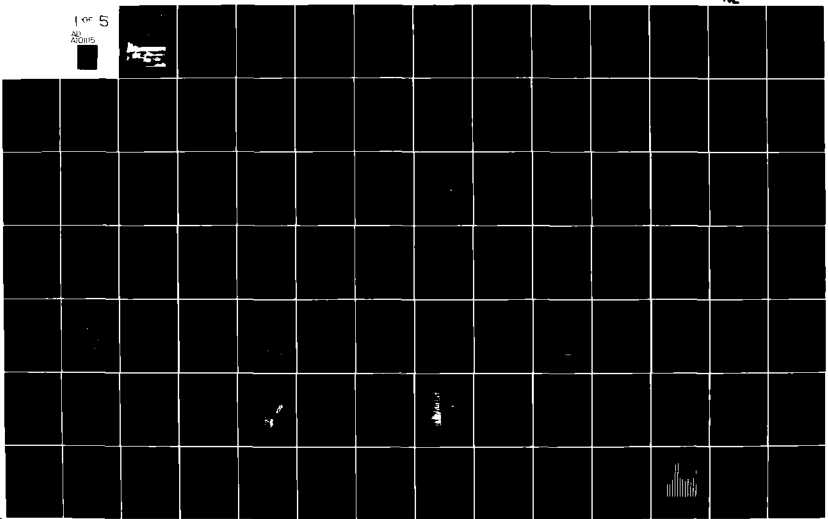


FINAL ENVIRONMENTAL IMPACT STATEMENT

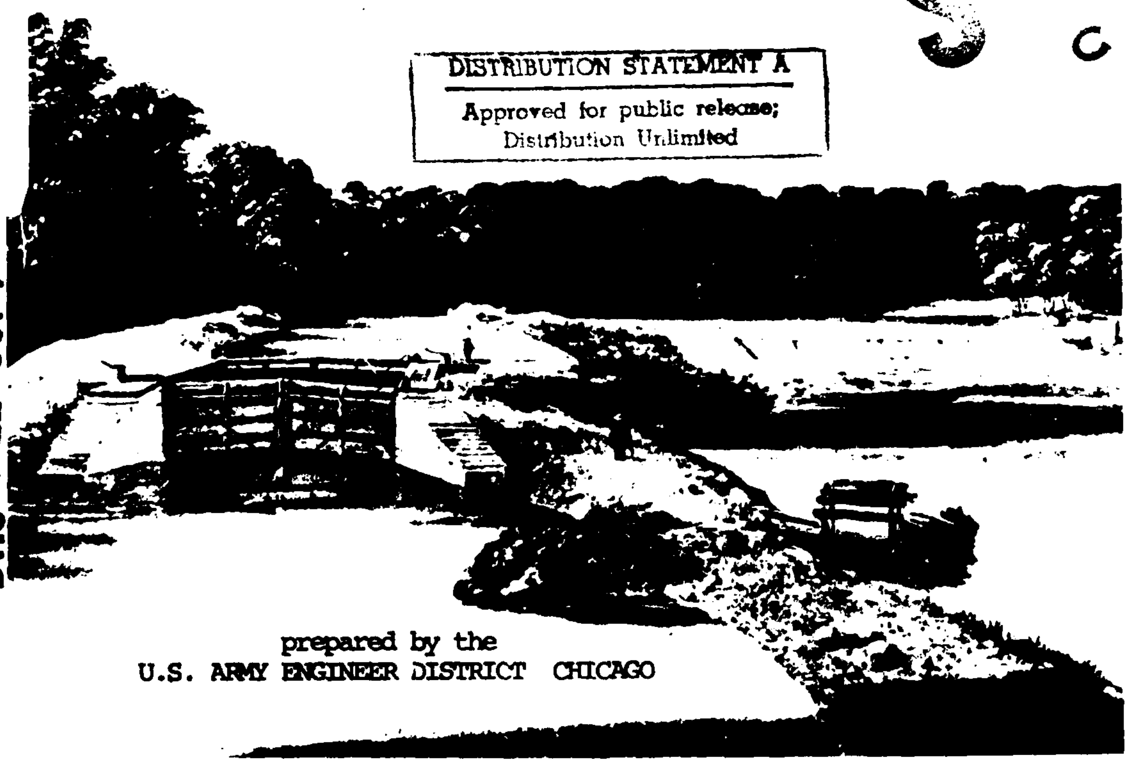
relating to the

OPERATION AND MAINTENANCE

of the

FOX RIVER, WISCONSIN NAVIGATION PROJECT

may 1977



prepared by the
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Lower locks at Grand Chute, Wis., on the Fox River, circa 1856
Painting by Samuel M. Brookes and Thomas H. Stevenson

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AQUATIC BIOTA	LAND USE	WATER QUALITY
DAMS	LOCKS OPERATION	
DREDGE MATERIAL	NAVIGATION	
DREDGING	SNAGGING	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The proposed Federal action is the continuation of operation and maintenance of the Fox River, Wisconsin navigation project. It involves several locks and guard locks, the U.S. dams, and control of private dams. Activities include channel dredging, clearing, snagging and dredge material disposal to free the channel from the debris.

Studies show major environmental impacts that are beneficial for
(Continued)

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20. ABSTRACT (Continued)

maintaining the project. It also relates significant adverse impacts on the water quality aquatic, and terrestrial biota, land use, natural habitat, and other conflicts in the operation of project and river controls. Alternatives to the proposed action are provided.

2

FINAL

ENVIRONMENTAL STATEMENT

relating to the

OPERATION AND MAINTENANCE
OF THE FOX RIVER, WISCONSIN NAVIGATION PROJECT

prepared by the

US ARMY ENGINEER DISTRICT

CHICAGO, ILLINOIS

May 1977

SUMMARY

OPERATION AND MAINTENANCE OF THE

FOX RIVER, WISCONSIN NAVIGATION PROJECT

( ) DRAFT (X) FINAL ENVIRONMENTAL STATEMENT

RESPONSIBLE OFFICE: U. S. Army, Chicago Engineer District,
219 South Dearborn,
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1. NAME OF ACTION: (X) ADMINISTRATIVE ( ) LEGISLATIVE

2. DESCRIPTION OF ACTION: The proposed Federal action is continued operation and maintenance of the Fox River, Wisconsin Navigation Project.

The activities involved in this project include:

(1) The operation and maintenance of 17 locks and 2 guard locks on the Lower Fox River between De Pere, Wisconsin and Lake Winnebago.

(2) Channel dredging, channel clearing and snagging, and dredge material disposal for: a six-foot navigation channel through the Lower Fox River and the Upper Fox River from Lake Winnebago at Oshkosh to its junction with the Wolf River in Lake Butte des Morts; four harbors of refuge on Lake Winnebago; and a four-foot channel through the lower Wolf River and Lakes Poygan and Winneconne.

(3) Operation and maintenance of nine U. S. dams on the Lower Fox River, including one dam which controls the water level of Lakes Winnebago, Butte des Morts, Winneconne, and Poygan.

(4) Control of the operation of four additional private dams on the Lower Fox River, including one dam which assists in the control of the water level of Lakes Winnebago, Butte des Morts, Winneconne, and Poygan.

Channel dredging is conducted as needed to satisfy current navigation requirements. Dredging is based on the reasonable needs of existing navigation and is therefore subject to periodic review and adjustment. Most of the dredge cuts are in areas such as alluvial fans at tributary confluences, deposition banks around bends in the river, and in the navigation channels above and below the locks. Historically, dredging in the amount of about 40,000 cubic yards has been required on an average annual basis. Periodic dredging and snagging will be required in future years to keep the channels free of debris.

Sites proposed as disposal areas are located throughout the project area. The sites to be used include previously used disposal sites along canal banks, the headrace of an abandoned hydropowered industrial site, and unusable farm field swales or low spots in public park land.

3. A. ENVIRONMENTAL IMPACTS - The major environmental impacts associated with the overall operation and maintenance of the existing Federal project are:

(1) Continuation of the navigation project assures a water transportation route from Green Bay, Wisconsin, through the Lower Fox River, to Lake Winnebago, and Lake Butte des Morts for craft having a six-foot or lesser draft. Water transportation from Lake Butte des Morts to New London via the Wolf River is also assured for craft having a four-foot or lesser draft.

(2) Channel dredging results in temporary increases in turbidity and suspended solids, removal of bottom organisms and substrate, and siltation. Dredged material removal promotes chemical exchange with previously buried bottom deposits. Dredging may also remove spawning shoals.

(3) Dredge material disposal can remove polluted materials from the waterways and contribute to or enhance land usefulness.

(4) Dredge material disposal destroys existing natural habitat and may result in leaching and runoff from the disposal sites and disturbance to existing or proposed land use.

(5) Operation of the locks and maintenance of the Lower Fox River for the purpose of recreational rather than commercial navigation requires the continued expenditure of public funds. Whether the recreational navigation benefits derived are sufficient to justify these continuing Federal expenditures is subject to more detailed examination.

(6) Under regulations that have been in effect since 1886, the United States has exercised its jurisdiction over the dams and other river controls on the Fox-Wolf River system for navigation. System operation for navigation and related purposes provides important local and regional water power, flood control, water supply, water quality, recreation, fish and wildlife, and land enhancement benefits. A number of conflicts have however arisen over the operation of these lake and river controls. Principally these relate to the effects of storage and release on upstream fish and wildlife and downstream water quality.

(7) For many years the primary control dams of the project system at Neenah and Menasha are believed to have produced significant adverse impacts on the natural habitat of the lakes and river upstream of the dams by contributing to high pool stages and fluctuating water levels.

(8) Under the basic plan for operation and use of water stored in Lake Winnebago, the rights of non-navigational interests are subservient to the prior rights of navigation. Under these circumstances, only a portion of the allowable range of lake level, and the allowable release of waters which might assist downstream water quality in the Lower Fox River has ever occurred.

B. ADVERSE ENVIRONMENTAL EFFECTS - The adverse environmental effects attributable to the ongoing project which cannot be totally avoided are:

(1) The effects of channel dredging on water quality and aquatic biota.

(2) The effects of dredge material disposal on water quality, aquatic biota, semi-aquatic biota, terrestrial biota, land use and natural habitat.

(3) The effects of navigation on shoreline erosion, water quality, aquatic biota, and semi-aquatic biota.

(4) The resource management conflicts over the operation of project lake and river controls.

4. ALTERNATIVES TO THE PROPOSED ACTION

A. Abandonment of the Lower Fox River Navigation System.

B. Discontinuation of Project Maintenance Dredging.

C. Abandonment of Lower Fox River Dams.

D. Transfer of the Federal Navigation Project to the State or Commercial Interests.

E. Partial Maintenance of Project Channels.

F. Use of Alternate Dredge Equipment.

G. Treatment of Polluted Dredged Material Prior to Disposal.

H. Discontinuation of Dredging Until All Disposal Sites Are Secured.

I. Selection of Other Disposal Sites.

J. Revision of Existing Project Flow Regulation Management Practices.

K. Improvement of Project Features for Recreation and Related Purposes.

5. COMMENTS RECEIVED: Comments on the draft environmental impact statement were received from the following:

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6. Draft Statement to CEQ 6 January 1976 .
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APPENDIX A

LIST OF TABLES

FINAL ENVIRONMENTAL IMPACT STATEMENT

RELATING TO OPERATION AND MAINTENANCE

OF THE FOX RIVER, WISCONSIN NAVIGATION PROJECT

Prepared in Accordance with Section 102(2)(C) of the
National Environmental Policy Act of 1969
Public Law 91-190

SECTION I

PROJECT DESCRIPTION

INTRODUCTION

1.01
The Fox River is located in east-central Wisconsin (see insert on Fig. 1.1). The existing project includes operation and maintenance work on the Lower Fox River from De Pere to Menasha; Lake Winnebago; the Upper Fox River from Lake Winnebago at Oshkosh to its junction with the Wolf River in Lake Butte des Morts; and the Wolf River from its mouth in Lake Butte des Morts to New London, Wisconsin. The Lower Fox River from its mouth to De Pere is part of the United States improvement of the Green Bay Harbor for deep-draft lake vessels. The Upper Fox River from Portage to its junction with the Wolf River, formerly part of the Fox River Federal Navigation Project, is now maintained by the State of Wisconsin for conservation and recreation purposes.

PROJECT AUTHORIZATION

1.02
Basic authorities for the operation and maintenance of the Fox River Project are contained in authorizing legislation of the U. S. Congress for construction of its various elements. Specifically, these are the River and Harbor Acts of 5 August 1886, 19 September 1890, 3 June 1896, 13 June 1902, 2 March 1907, 3 March 1925, and 26 June 1934. Section 108 of the River and Harbor Act approved 3 July 1958 transfer of the Federal project structures, appurtenances, and real property pertaining to the Upper Fox River portion of the project to the State of Wisconsin. This transfer was made by deeds dated 27 June 19[illegible]2.

THE FEDERAL PROJECT

Early History

1.03
Considered from the standpoint of historical associations, the Fox River system has played a major role in the history and economic development

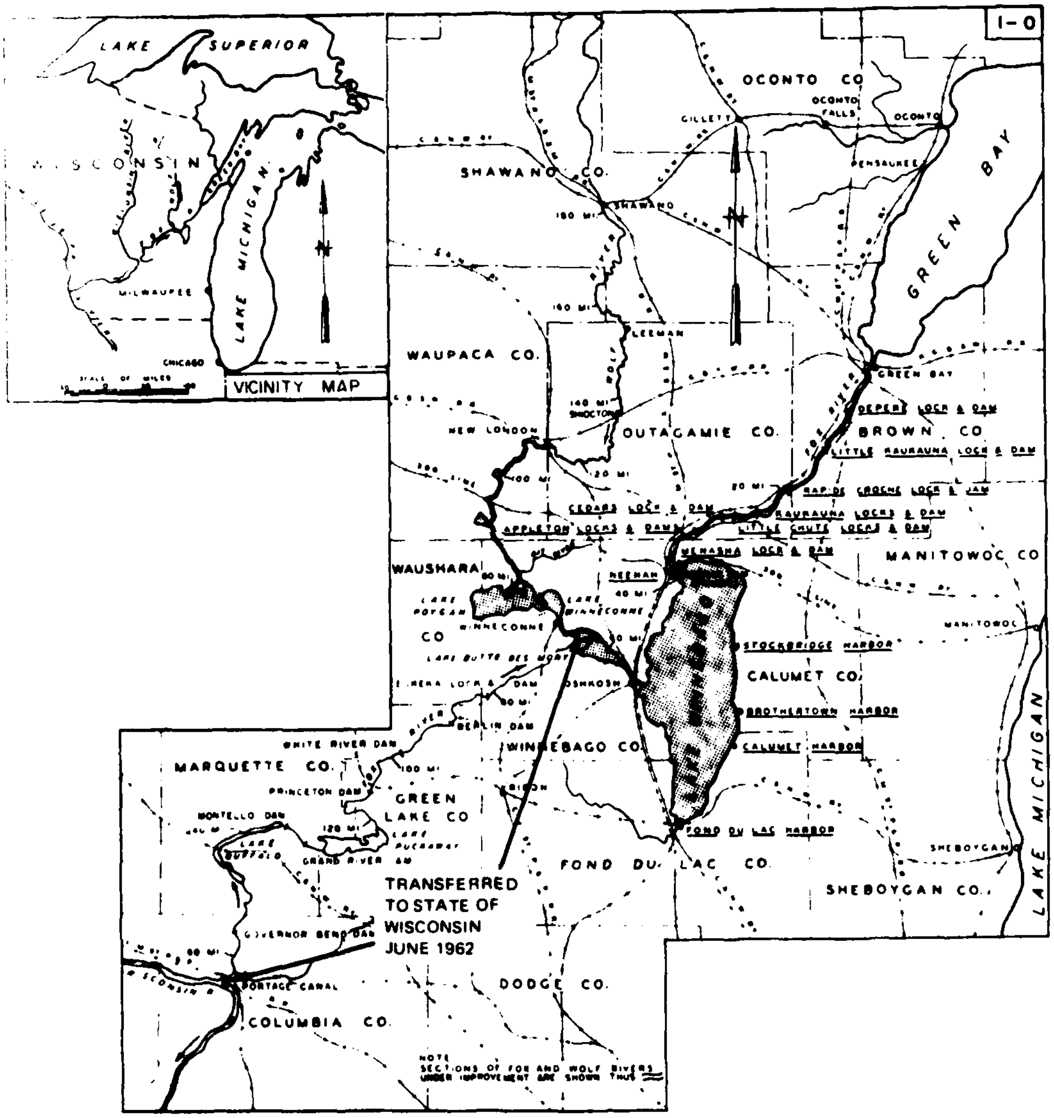


Fig. 1.1. Location of the Fox River Project

of Wisconsin. It was the route that the first white men used to penetrate into Wisconsin, and later was the earliest artery of commerce into the interior of the state.

1.04
The first survey to determine the best practical plan for improving the Fox-Wisconsin River route for navigation resulted from instruction issued by the U. S. War Department in April 1837, the year following Wisconsin's organization as a territory. A report by Captain T. J. Cram, dated January 1840, was published as a Senate Document of the 26th Congress. The first attempt by the United States to improve the river was through the Congressional Act of August 1846, authorizing a grant of land to the State of Wisconsin for which the State was to improve the Fox and Wisconsin rivers and provide a canal at Portage to connect them. The grant was accepted by the State on 29 June 1848, and by its Act of 8 August 1848, the State placed the work of improvement under a State board of Public Works. After some initial work, the State vested further improvement of these rivers in the Fox and Wisconsin Improvement Company, a private corporation, by an Act of 6 July 1853. The plan of this company provided for free passage of boats drawing less than 4 feet on the Lower Fox River and 2 feet on the Upper Fox River at ordinary low water, with locks 160 feet long, 35 feet wide, having a depth of 5 feet over the miter sills. This company, having failed to accomplish the improvements required by the State legislation, lost control of the project. The entire improvement was sold by the trustees for the Improvement Company on 15 August 1866 to the Green Bay and Mississippi Canal Company, another private corporation. This company remained in charge of the improvement until 1872. Through provisions of the Acts of Congress of July 1870 and June 1872, the United States bought out the Green Bay and Mississippi Canal Company and took charge of works of improvement pertaining to navigation, the company retaining the rights with respect to water power. The deed of transfer from the company to the United States, dated 18 September 1872, gave the United States title to all:

> "... locks, dams, canals, and franchises, saving and excepting therefrom and reserving" to the company 'the water power created by the dams and by the use of surplus water not required for the purpose of navigation, with the rights of protection and preservation appurtenant thereto, and the lots, pieces, or parcels of land necessary to the enjoyment of the same and those acquired with reference to the same, all subject to the right to use the water for all purposes of navigation."

In accordance with the deed of transfer, therefore, water power users on the Lower Fox River are entitled to all surplus water not needed for navigation. Conversely, the rights of these users are expressly subservient to the prior requirements of navigation.

1.05
The first general plan for the improvement of the Fox and Wisconsin rivers by the Federal Government was contained in the River and Harbor Act of 3 March 1873. The plan of improvement adopted under this Act

provided for repair and replacement of the then existing works on the Fox River, construction of additional locks and dams to complete the system of slack water navigation on the Upper Fox River, and the improvement of the channels and the replacement of all existing locks and dams by permanent structures on the Wisconsin River. However, the impracticability of maintaining navigation on the Wisconsin River was realized rather early and the Wisconsin River improvement was abandoned by the Federal Government in the year of 1887 on the report and recommendation of the Board of Engineers. In 1886 the general plan was modified to include various improvements in harbors on Lake Winnebago. Finally, according to the Congressional Act of 3 June 1896, the general plan was also modified to provide for navigation improvements in the Wolf River above Fremont to New London.

Authorized Federal Project

1.06
The authorized Federal project provides for deepening and widening the channel of the Fox River from De Pere, 7 miles above the mouth, to the confluence of the Wolf River, a total length of 59 miles at a depth of 6 feet in soft materials, 9.6 feet in the rock cut below De Pere lock and 7 feet in other rock cuts on the lower river below the Menasha lock; for the construction and reconstruction of 17 locks, 2 guard locks, and 9 dams; for a concrete retaining wall at Kaukauna; for construction and maintenance of harbors having depths of 6 feet at Fond du Lac, Stockbridge, Calumet, and Brothertown Harbors on Lake Winnebago; for widening the Neenah Channel to 100 feet, with a 6-foot depth for about one mile; and for dredging, snagging, and otherwise improving the Wolf River from its mouth to New London, a distance of 47 miles, to a depth of 4 feet. All depths are referred to standard low water which is 576.8 feet MSL. Project maps showing the extent and status of the authorized project are included in Appendix A of this report.

1.07
The controlling dimensions of the existing Fox River locks are generally 144 feet long, 35 feet wide, with a minimum depth of 6 feet over the miter sills and breast walls when the navigation pools are at standard low water level. Since flash boards are used on most of the dams during the low water season additional depths of 6 inches to 1.5 feet are quite generally available, except above the Appleton upper dam and the Menasha dam. The lift at the locks varies from 7.2 feet at Little Kaukauna to 13.8 feet at Little Chute second lock at normal pool levels. The locks on the Lower Fox River are equipped with manually operated gate and valve operating mechanisms. The dams are of a fixed type, consisting of both spillway and sluiceway sections. The overall dimensions and number of sluice gates vary at each site to fit local conditions, such as width of stream, probable flood stage, variation of flow, head of water involved and discharge capacity of adjoining hydroelectric power plants or mills. Table 1.1 summarizes the physical characteristics of the existing locks and dams on the Lower Fox River. See the project maps provided in Appendix A for more detailed information. A profile of the Lower Fox River is shown in figure 1.2.

Table 1.1. Lock and Dam Characteristics, Lower Fox River, Wisconsin

Name of Lock and Dam	Miles from Green Bay	Nearest Town	Distance (mi)	Clear Width (ft)	Available Length (ft)	Lift (ft)	Depth at Normal Pool: Breast Wall[a] (ft)	Depth at Normal Pool: Lower Miter Sill (ft)	Character of Foundation	Kind of Dam	Type of Construction	Year Complete	Actual Cost
De Pere lock[b]	7.1	De Pere	-	36.0	146.0	8.9	10.3	1[illegible].0	Rock	-	Concrete	1936	$229,308
De Pere dam[b]	[illegible]	De Pere	-	-	-	-	-	-	Rock	Fixed[c,d]	Concrete	1929	209,536
Little Kaukauna lock[b]	13.0	De Pere	6	36.0	146.0	7.2	8.0	9.5	Clay	-	Concrete	1938	362,427
Little Kaukauna dam[b]	13.1	De Pere	6	-	-	-	-	-	Clay and gravel	Fixed[c,d]	Piers and concrete	1926	179,398
Rapide Croche lock[b]	19.2	Wrightstown	2	36.0	146.0	8.3	8.3	9.3	Rock	-	Concrete	1934	228,738
Rapide Croche dam[b]	19.3	Wrightstown	2	-	-	-	-	-	Rock	Fixed[c,d]	Concrete	1930	118,975
Kaukauna fifth lock[b]	22.8	Kaukauna	-	35.6	144.0	9.1	6.7	7.4	Rock	-	Composite	1898	13,310[e]
Kaukauka fourth lock[b]	23.1	Kaukauna	-	36.6	144.1	10.2	6.9	6.0	Rock	-	Stone masonry	1879	37,536
Kaukauna third lock[b]	23.3	Kaukauna	-	30.6	144.0	10.2	6.9	6.3	Rock	-	Stone masonry	1879	39,948
Kaukauna second lock[b]	23.4	Kaukauna	-	35.0	144.0	9.6	6.0	6.0	Rock	-	Stone masonry	1903	24,313
Kaukauna first lock[b]	23.6	Kaukauna	-	35.1	144.4	11.0	6.9	6.0	Rock	-	Stone masonry	1883	38,704
Kaukauna dam[b]	24.0	Kaukauna	-	-	-	-	-	-	Rock	Fixed[c,d]	Concrete	1931	123,763
Kaukauna guard lock	24.0	Kaukauna	-	40.0	-	-	9.4	-	Rock	-	Stone masonry	1891	12,630
Little Chute combined lock:													
Lower	24.4	Little Chute	1	35.4	146.5	10.9	6.0	8.6	Rock	-	Stone masonry	1879	102,304
Upper	25.4	Little Chute	1	36.3	144.1	10.6	7.6	6.0	Hardpan	-	Stone masonry	1879	
Little Chute second lock[b]	26.4	Little Chut	-	35.0	144.2	13.8	8.0	6.1	Rock	-	Stone masonry	1881	48,555
Little Chute first (guard) lock[a]	26.5	Little Chute	-	35.4	-	-	6.6	-	Rock	-	Stone masonry	1904	7,817[e]
Little Chute dam[b]	26.6	Little Chute	-	-	-	-	-	-	Rock	Fixed[c,d]	Concrete	1932	82,554
Cedars lock[b]	27.3	Little Chute	1	35.0	144.0	9.8	6.8	7.3	Rock	-	Stone masonry	1888	34,972
Cedars dam[b]	27.4	Little Chute	1		-	-	-	-	Rock	Fixed[c,d]	Concrete	1933	84,973
Appleton fourth lock[b]	30.7	Appleton	1	35.0	144.0	7.6	8.1	7.9	Rock	-	Stone masonry	1907	40,893
Appleton lower dam[b]	30.9	Appleton	1	-	-	-	-	-	Rock	Fixed[c,d]	Concrete	1934	73,903
Appleton third lock[b]	31.3	Appleton	-	35.0	144.0	8.7	6.0	8.6	Rock	-	Stone masonry	1900	32,238
Appleton second lock[b]	31.6	Appleton	-	35.1	144.6	9.6	6.9	6.0	Clay	-	Stone masonry	1901	22,940
Appleton first lock[b]	31.9	Appleton	-	35.0	144.7	10.0	6.6	6.0	Rock	-	Stone masonry	1884	36,004
Appleton upper dam	32.2	Appleton	-	-	-	-	-	-	Rock	Fixed[c]	Concrete	1940	151,558
Menasha lock[b]	37.0	Menasha	-	35.4	144.0	8.[illegible]	7.[illegible]	8.0	Clay	-	Composite	1899	19,326[e]
Menasha dam[b]	37.8	Menasha	-	-	-	-	-	-	Hardpan	Fixed[c]	Concrete	1937	54,686

[a]Depth shown is on breast wall, which [illegible] ces.

[b]Original structure [illegible] on September 18, 1872. [illegible]

1.08
The Federal project approved by the Secretary of War on 10 December 1884, and modified 14 May 1886 by authority of the Chief of Engineers, also provided for improving the Upper Fox River channel from its mouth to Portage, Wisconsin. The project provided for a channel having a depth of 6 feet and a width of 100 feet for a length of 66 miles to Montello; a depth of 4 feet from Montello to Portage, an additional 28 miles; with 9 locks and 7 dams, and a canal at Portage connecting the Fox and Wisconsin Rivers. The title to the Upper Fox River navigation improvement was transferred to the State of Wisconsin by quit claim deed dated 27 June 1962, as authorized by Section 108 of the 1958 River and Harbor Act (PL 85-500; 72 Stat. 301), and is no longer part of the existing project.

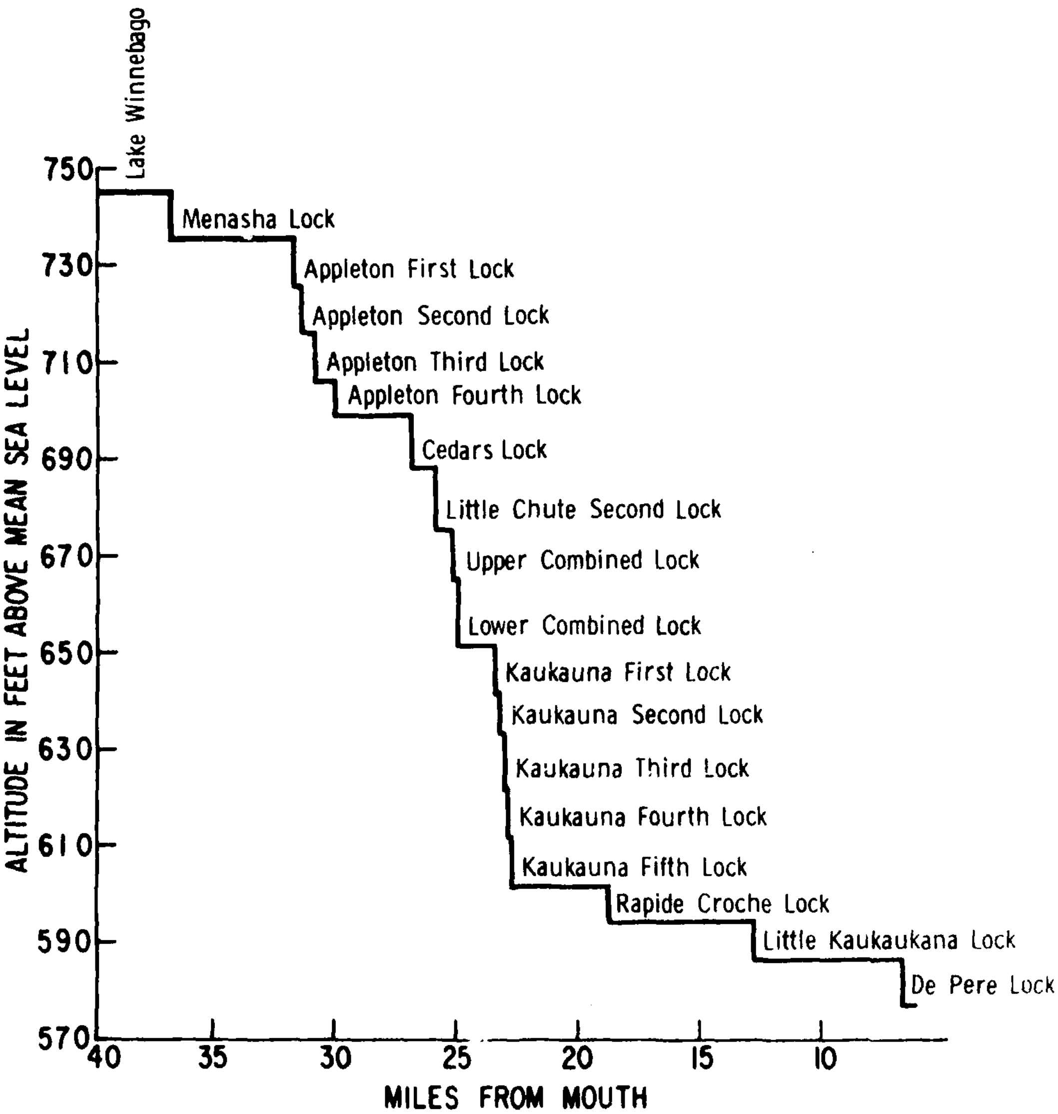


Fig. 1.2. Lower Fox Waterway Profile

Status of the Authorized Plan

1.09
The authorized project is complete except for portions now classified inactive. These inactive portions consist of deepening the Wolf River between Lake Poygan and New London to a depth of 6 feet, deepening the Neenah Channel to a depth of 6 feet, and rock removal at five locations in the lower Fox River to a depth of 7 feet. The work remaining to totally complete the authorized project is no longer required to accommodate commercial navigation traffic.

Improvements Desired

1.10
Commercial navigation on the rivers and connecting lakes was discontinued in 1959, except for an occasional movement of a contractor's floating construction or dredging equipment, a commercial fishing boat, or a houseboat, barge, or other water-craft built in the area for delivery to customers on the Great Lakes. However, local interests are generally strongly opposed to any change in the operation or care of the waterway, mainly because of the heavy use by recreational boating traffic which is increasing rapidly in the area. Frequent requests have been received for the removal of shoals, snags, or other impediments to recreational boating. Local municipalities and water power interests also are vitally interested in the maintenance and operation of the government-owned dams because of their effect on water power development, sanitary conditions, shorelands, etc. Frequent requests from various boating groups and other local interests have been made to have the natural Neenah Harbor of refuge activated.

Condition of the Project

1.11
Except for the Menasha lock, the existing locks and dams are in generally fair to good condition. They should continue to give reliable service with normal maintenance. The Menasha lock is in poor condition and is scheduled for major rehabilitation during calendar years 1978 and 1979.

Local Cooperation on Existing and Prior Projects

1.12
No local cooperation is specifically required by acts authorizing the project. The original Federal authorization for improvement of the Fox River is the U. S. Congressional Act of 8 August 1846. Improvements were started under various State acts and contracts, and under provisions of a State act dated 3 October 1856 the entire improvement work was sold by the State on 15 August 1866 to the Green Bay and Mississippi Canal Company. Under the provisions of Congressional Act of 10 June 1872 the

United States paid the Canal Company $145,000 and took title to all the navigation improvements owned by that company.

1.13
Records indicate that the Neenah dam was originally built by private interests without cost to the State, "in consideration of the use of the water power." This dam was not included in the property acquired from the Green Bay and Mississippi Canal Company as it was not owned by that company. It has always been maintained by private interests subservient to the requirements of navigation and laws relative to regulation of Lake Winnebago. The present owner of all the water rights at Menasha and Neenah is the Neenah and Menasha Water Power Company, and that company is responsible for maintenance of Neenah dam under State laws. Although this dam is an essential part of the navigation project to maintain Lake Winnebago water levels, its construction and maintenance have not been specified items of local cooperation required by the project authorizations. A portion of the DePere dam also is privately owned and maintained and, although required to maintain the pool level above the DePere lock, it is not specified as an item of local cooperation in the project.

IMPROVEMENTS BY LOCAL INTERESTS

1.14
Many boat landings, piers, mooring basins, boat launchways or hoists, storage sheds, and other facilities to serve the hundreds of non-commercial or recreational boat owners operating their boats on the waters of the Fox and Wolf Rivers and connecting lakes have been developed by the State, counties and local municipalities, and by private Although these facilities are provided by local interests, the value of such improvements is largely dependent on the accessibility of a wide range of cruising water possible because of maintenance and operation of the Federal project. Expansion of such facilities as the number of boats in use increase is continuing. Motor fuel and other needed supplies are available at most of these marinas, and at numerous other service stations along the waterways. Most of the marina improvements include parking spaces for visitors' automobiles and boat trailers and have launchways or hoists for launching trailer-hauled boats. Many of the operators provide rental boats and motors and other equipment for water-based recreational activities. Winter storage space for boats is available although most of the larger cruisers leave the area for storage, winter overhaul, and maintenance service at shipyards or boat repair facilities at Lake Michigan harbors. Many public and private launchways are available to give owners of trailer-hauled boats access to the public waters and are widely used by people from the eastern half of the state, with many visitors from northern Illinois and Indiana and more distant areas. Access points are fairly well distributed around the various lakes and pools and provide convenient access points for the using boatmen. Most of the launching facilities are available to the public without launching charges.

PROJECT OPERATIONS AND MAINTENANCE DESCRIPTION

General

1.15
The activities conducted by the Chicago District in maintaining the navigable channel include operation and maintenance of nine U. S. dams, seventeen locks and two guard locks, channel clearing and snagging, channel dredging, and dredge material disposal. Dams are operated to maintain sufficient pool elevations for navigation. Repairs to the existing locks and dams are performed when needed to insure safe and effective operation. A clamshell dredge is used to remove channel obstructions and deposited sediments, as necessary, and to maintain authorized channel depth in conjunction with pool elevations. Dredge materials are placed on preselected disposal sites.

Navigation

1.16
The existing Federal project was designed primarily to accommodate commercial barge transportation of coal and other bulk commodities. There is no regular commercial traffic on the Fox or Wolf Rivers or Lake Winnebago at the present time. Except for intermittent usage by Coast Guard and commercial fishing vessels, navigation is almost entirely recreational in character. Contractors also make occasional use of the waterway for the movement of dredging or construction equipment and materials, for work on the many bridges and waterfront structures, or for improvement of marinas and small craft mooring areas. An example of the intermittent use by contractors' equipment was the movement during the 1968 season of a 157-ton paper mill dryer from Green Bay to Kaukauna. Government owned and operated dredging and construction equipment used for maintaining locks and dams, removing shoals, and clearing snags also makes use of the waterway.

1.17
The most recent regular freight traffic was the barge hauling of coal from docks at Green Bay to various paper mills and public utilities along the Lower Fox River. This service was discontinued at the close of the 1959 navigation season. The principal factors causing the decrease and final suspension of the traffic in coal were the introduction of oil and gas fuels, transmission of electric power into the area from other areas, the rising costs of operating tugs and barges, and the railroad and improved highways along the river which made land transportation more economic than waterborne movement. There appears no economic advantage in, and no prospect of resumption of, barge traffic.

1.18
Today the project is primarily used only by recreational craft, the peak traffic being in the summer and fall. The Lower Fox River is the connecting waterway between the Green Bay arm of Lake Michigan and the popular recreational boating area of Lake Winnebago and the Wolf River to

New London. Lake Winnebago and the Wolf River are connected by Lakes Butte des Morts, Winneconne, and Poygan, which together have a total area of about 265 square miles. These waters are a very popular recreational boating area attracting boaters from a wide midwestern area, as well as serving the local residents and the large summer vacation population. During the 4-year period 1972-1975, the average annual number of lockages at the 16 Lower Fox River locksites was 11,919. The number of boats passed through the locks averaged 18,528 per year, an average of 1.56 boats per lockage. This traffic is handled during a navigation season of about 185 days, normally extending from about 1 May to 1 November. The average annual number of lockages and boats passed during the 4-year period at Menasha lock, where there is a heavy demand for access to Lake Winnebago by boatmen from the Appleton and Neenah-Menasha urban areas, was 2,532 and 4,112, respectively. At DePere, where there is considerable demand for passage to the pools above the DePere and Little Kaukauna dams by boatmen from the Green Bay metropolitan area, the average annual number of lockages was 1,722 and the average number of boats passed was 2,629. Between the Little Kaukauna lock and Menasha lock, the average annual number of lockages per lock varied from 434 to 520, and the average number of boats passed ranged from 709 to 774. Many of these craft made the complete trip from Green Bay to Lake Winnebago or returned. The heaviest traffic at all the locks usually occurs in July at the height of the vacation season. Further information on traffic at the various locks is included in Section 2.

1.19
The waterway traffic consists primarily of recreational vessels such as outboards, inboards, cruisers (outboard and inboard), houseboats, sailboats, auxiliary sailboats, rowboats, and canoes. The vessels using the waterway vary in sizes from 12.0 to 65.0 feet in length, 4.0 to 17.0 feet in breadth and require 6 inches to 6 feet of water depth.

1.20
Lock and Dam Operation - The Fox River navigation system is operated by personnel who serve as lockmaster or lockman in their duties in supervising the movements of navigation and regulating river flows in the vicinity of the locks and/or dams under their jurisdiction. The locks are operated daily during the 185-day recreational boating season from 1 May to 1 November. Two locks operate 16 hours per day, 7 days per week; the remaining 15 locks operate one 8-hour shift per day, 7 days per week during a 185-day recreational boating season. Lockages are provided during certain other hours at the 15 locks but only by prior request. Additional detailed information on lock operation and lock regulation procedures is contained in Appendix A of the draft environmental statement. Table 1.2 lists each of the existing dams along the Lower Fox River. Table 1.3 gives the general regulation regarding the operation of these dams. Detailed regulation information for each dam can be found in Appendix A of the draft environmental statement.

Table 1.2. Dams of the Lower Fox River, Wisconsin

Location	Name	Crest Elevation	Operator, Agency, or Company
River Mile 38	Menasha	745.03	Federal Gov't (Corps of Engineer
River Mile 38	Neenah	744.95	Neenah-Menasha Water Power Company (Kimberly Clark)
River Mile 32	Appleton (Upper)	735.4	Federal Gov't (Corps of Engineers
River Mile 31	Appleton (Middle-Private)	719.67 (Top of sluicegate)	Fox River Paper Co. et al.
River Mile 30	Appleton (Lower)	706.25 (706.75 with 6" flashboards)	Federal Gov't (Corps of Engineers
River Mile 27	Cedars	698.66 (699.16 with 6" flashboards)	Federal Gov't (Corps of Engineers
River Mile 26	Little Chute	688.88 (689.38 with 6" flashboards)	Federal Gov't (Corps of Engineers)
River Mile 25	Combined Locks (Private)	673.86 (675.86 with 24" flashboards)	Combined Locks Paper Co. (Appleton Papers, Div. of NCR)
River Mile 23	Kaukauna (Upper)	652.76 (653.36 with 6" flashboards)	Federal Gov't (Corps of Engineers)
River Mile 22	Kaukauna (Lower-Private)	628.3	City of Kaukauna's Electric and Water Utility
River Mile 21	Rapide Croche	602.15 (604.65 with 30" flashboards)	Federal Gov't (Corps of Engineers)
River Mile 15	Little Kaukauna (Little Rapids)	592.80 (594.80 with 24" flashboards)	Federal Gov't (Corps of Engineers)
River Mile 7	De Pere[a] (U. S. portion)	586.66 (587.66 with 12" flashboards	Federal Gov't (Corps of Engineers

[a]A private section of the De Pere dam located west and adjacent to the Federal dam is owned by the Nicolet Paper Company. This section has a spillway structure 332 feet in length.

Table 1.3. General Regulations Regarding the Operation of the Dams on the Lower Fox River

(1) Maintain and regulate the upper pools of the dams within prescribed limits by the removal and placement of flashboards and the opening and closing of sluice gates are in accordance with the policies, guidelines, and operating procedures as outlined and provided by the Appleton Project Office.

(2) Basically, the taintor gates will be operated so as to distribute the discharge of water evenly. The release of water may, however, be distributed irregularly to break up cross currents, currents washing banks, or currents adversely affecting the navigation approaches to locks, dams, or other critical sections of the channels and canals.

(3) Pools will be maintained near their prescribed upper limits during extended freezing weather period. When ice conditions prevail and if the water level permits, one to three gates depending on the locality may be left opened at the bottom for three to four inches to prevent ice from forming on the face of the gate.

(4) Taintor gates which may become inoperative due to ice will be freed and kept in a condition to permit prompt openings. Spillways on dams will also be freed of ice at all times.

(5) Discharge of water should be regulated to minimize the possibility of fish kills in the pools above and below the dams due to a sharp lowering of the water levels.

(6) In an emergency, flashes or waves of water may be released from the storage pools to assist a grounded vessel, or for a stagnant condition that may prevail in the lower pools.

Operation during Low Flows - Regulations on the Fox River prohibit the drawing of water levels below the crests of the controlling dams by the adjoining power plants or paper mills.

(1) Pool levels during low flows will be controlled and regulated as close to the upper limits as prescribed in accordance with the policies, guidelines, and operating procedures as outlined and provided by the Appleton Project Office.

(2) The placement of flashboards on the dams to raise the pool levels is permitted where permission has been authorized.

Operations during High Flows - The rise in the stage in the upper pools will be regulated by means of the taintor gates in the dams.

(1) Flashboards shall be removed promptly whenever the stage of the upper pools approach the upper water limits.

(2) When release of water from the dams become necessary, sluice gates shall be opened to keep the water levels within the prescribed limits.

(3) Predicted increase river flows will require pools to be maintained near their lower limits.

(4) Temporarily closures of some sluices in dams to assist vessels to by-pass the dams is authorized. Opening of the sluices again immediately after the passage is required to maintain the pool level within the regulatory limits.

Action - Implementation of the policies above are set forth in accordance with the operating procedures as outlined and provided by the Appleton Project Office.

Reports - The Appleton data required and the manner prescribed is in accordance with the guidelines provided by the Project Office. Sluicing and flashboard operations, gage readings, and violations of water regulations by adjoining plant and mill operators are some of the essential information needed to achieve the objectives defined above.

1.21
Channel Maintenance - Maintenance dredging is required at various times to maintain adequate channel depths based on the reasonable needs of existing navigation. Dredging is performed by clamshell dredge. Auxiliary equipment, consisting of scows and tugboats, is required to transport the dredged materials to approved disposal sites. The existing channels are adequate for all current navigational requirements. Dredging is normally accomplished between May and October. Scheduling of dredging operations is determined by a number of factors such as need for dredging, availability of equipment, and weather conditions. In determining the time when dredging will take place, environmental factors are given as much consideration as possible in scheduling work.

1.22
Dredging is required in the narrow restricted channels above and below the locks and at restricted river sections between locks on the Lower Fox River, and at each of the Federal harbors of refuge on Lake Winnebago (See maps and charts in Appendix A).

1.23
The authorized project for channel improvement on the Wolf River provides for dredging and snagging as necessary from its mouth in Lake Butte des Morts to New London to maintain a 4-foot depth in the navigation channel. To maintain navigability on the Wolf River, it is necessary to perform snagging and dredging operations approximately every four years. One of the problem areas where frequent maintenance dredging is required is in the cut-off channel at Boom Cut through the shoal waters of Lake Poygan. This channel extends from the north shore of Lake Poygan to a point about 1.1 miles south of the Wolf River entrance into the lake. Boom Cut is about 15 miles above the mouth of the Wolf River in Lake Butte des Morts. It is located in a very low area of Lake Poygan where it is exposed to considerable drifting sediments, dislodged bog material, and sediments carried down from the river by flood currents. Extensive recreational boating use of much of the Wolf River segment of the project has been made possible primarily by the improvement and maintenance of this channel The natural depth of the river below Freemont, except for Boom Cut at the head of Lake Poygan and for 10 miles above Fremont, is in excess of 4 feet and only occasional dredging and snagging is required to keep the channel clear for navigation. In the remainder of the river to New London, shoaling occurs more frequently. In addition, many fallen trees, snags, and submerged logs are also found in this section of the river and are removed to improve safety for the navigation of recreational boating. The snagging operations consist of removing fallen trees, stumps, and other debris. No trees are cut unless they are completely fallen over and are either obstructing or have the potential to obstruct the navigable channel. Materials dredged from the Wolf River, consist mainly of sand, silt and clay. Specific dredging locations within the project and quantities to be dredged vary from year to year depending upon local runoff from tributaries that discharge into the Wolf River. Areas of shoaling in the river may vary but for the most part have occurred most frequently at the locations listed below and shown in Fig. 1.3

Dredging Site	River Mile Location	Quantity Cubic Yards
Above Red Banks	34.5	2,150
Below Devil's Elbow	42.75	2,222
Above Guth's Landing near Black Bass Bend	44.5	741
Above Parfitt's Landing	47.75	1,850
At Shaw's Landing	48.75	3,110
Below the entrance of the Little Wolf River	50.0	2,705
At the mouth of the Little Wolf River	50.1	1,491
Below Yacht Club at New London	55.75	2,300

1.24
A recent history of maintenance dredging and snagging performed on the Wolf River is as follows:

Calendar Year 1964	
Submerged logs removed	302
Leaning trees removed	744
Snags removed	914
Dredged material removed	7,120 cu. yds.

Calendar Year 1967	
Submerged logs removed	917
Leaning trees removed	2,213
Snags removed	1,881

Calendar Year 1971	
Submerged logs removed	137
Leaning trees removed	835
Snags removed	426
Dredged material removed	525 cu. yds.

1.25
Dredged Material Disposal - Until additional improvements are made to abate pollution the materials to be dredged from the Lower Fox River, Neenah Channel, Fond du Lac Harbor, and possibly at other locations, will be heavily polluted. Under present Federal policies such dredge materials cannot be disposed of in the river or lake as has been the usual practice in the past. Consequently, it is necessary to confine any dredgings which do not meet established U. S. Environmental Protection Agency sediment quality guidelines. The proposed plan for

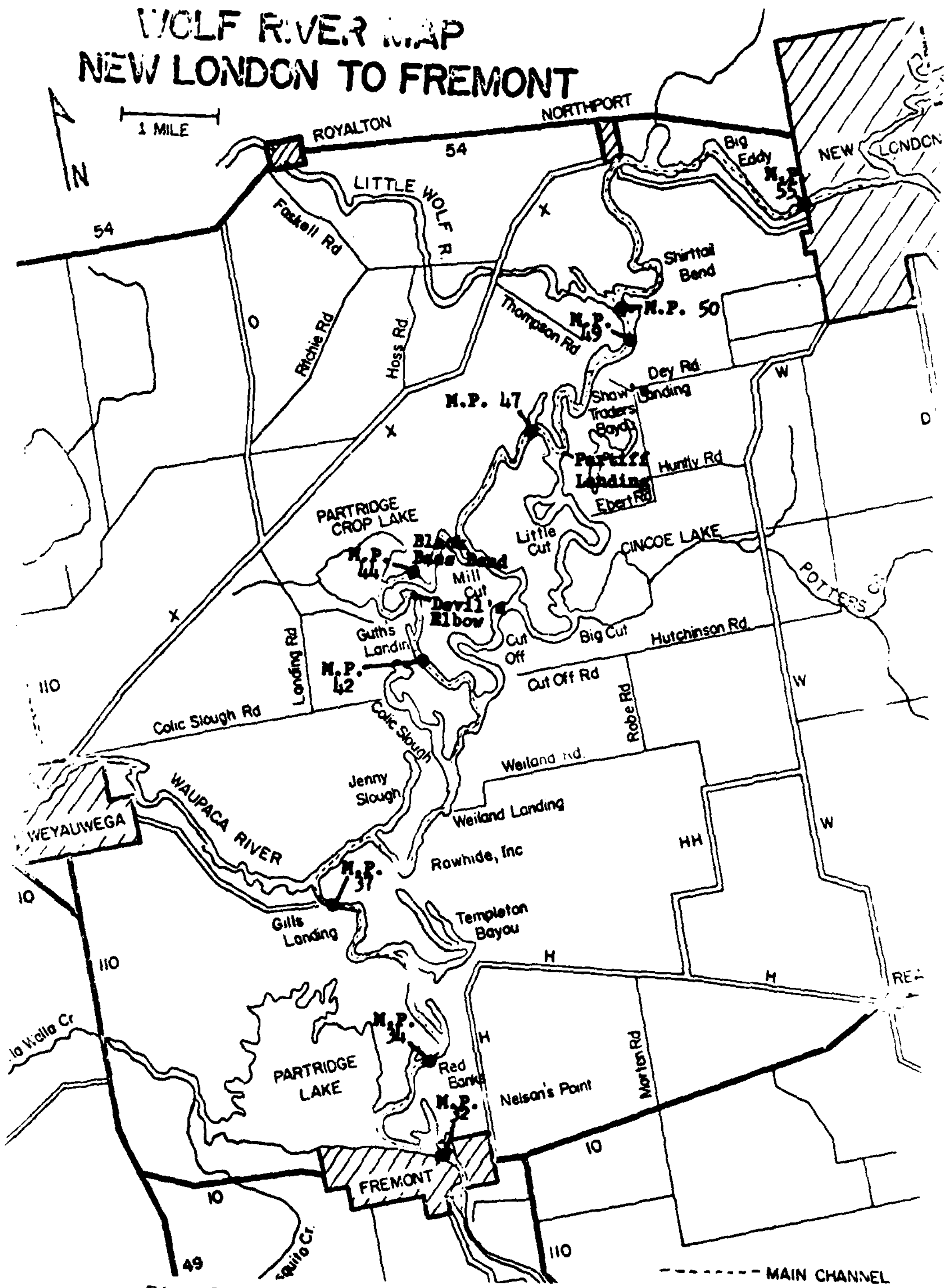


Fig. 1.3. Wolf River Locations Most Frequently Requiring Channel Maintenance

future maintenance is to provide disposal areas on shore, or within completely confined areas, for dredged materials which are polluted or would increase pollution if deposited in navigable waters.

1.26
Dredged material disposal of about 40,000 cubic yards is required on an average annual basis. Table 1.4 lists the primary land sites used for disposal of dredged materials during the last ten years. Table 1.5 presents a list of anticipated dredging sites and the probable most advantageous disposal sites for each area. Figures 1.4-1.16 show the location of Federally and State approved disposal sites listed in this table.

1.27
Generally these sites are small containment areas along shore inclosed by dikes prepared in cooperation with local interests. Usually riprap or other protection of the river or lake side of the dike will be provided to prevent excessive erosion due to flooding or wave action. In some cases the acquisition of additional property rights will be required. In other cases the approval of local public officials will be needed, with an agreement for local assistance in distribution of dredged materials deposited on the stream or canal banks. In the single instance where it is proposed to deposit dredged materials in shoal waters, a substantial dike to inclose that area and prevent the escape of polluted material to the river will be required. Dredged materials at some project area locations have also been identified for agricultural or commercial fill use. In these instances dredged materials are stockpiled and/or rehandled and transported by local interests for disposal on an as needed basis. Specific locations for eventual disposal are determined by local interests but are subject to Federal and State regulatory requirements, reviews, and approvals.

1.28
Dredged material disposal will initially be limited to the plan described in Table 1.5. Sites will be developed in accordance with actual dredging and disposal needs. Selected sites will be filled at the earliest possible time after its use begins. When a site is used, every effort will be made to develop it to its fullest potential and thereby reduce the total number of sites impacted. As the need for additional disposal sites arises, maintenance dredging will continue to be performed, subject to the disposal of dredged materials at approved disposal sites.

1.29
Canal Banks - The canal banks (see Appendix A) that have been constructed to maintain pool levels for navigation and power are generally clay fill with masonry retaining walls, and stone riprap in areas subjected to strong currents or erosion from boat wave wash. The canal banks are generally of adequate height and in good condition, but require some maintenance annually due to settling, storm water erosion other deterioration.

Table 1.4. List of Primary Sites for the Disposal of Dredged Material

Dredging Location	Disposal Site	Ownership of Disposal Site	Dimensions of Site	Age of Deposits
Fond du Lac Harbor (Lake Winnebago)	Lakeshore. Cover for sanitary fill.	City of Fond du Lac	250' × 1000'	1.75 years
Calumet Harbor (Lake Winnebago)	On agricultural lands.	Bernard Berger Farm	Upland area east of barn estimate 2-3 acres	4.75 years
Wolf River (Boom Cut)	Right side of channel on existing dredge banks.	Lake Poygan Land Co.	75' × 2500'	3.6 years
Menasha Channel (below lock)	Left side of channel on existing dredge banks.	State of Wisconsin	60' × 1200'	9.5 years
Navigation Canal between Appleton 1st & 2nd locks	Right side of canal on existing bank above Appleton 2nd lock.	United States	30' × 200'	8.75 years
Channel below Appleton 4th lock	Left side of channel below Appleton 4th lock on existing dredge banks.	United States	50' × 400'	8.8 years
Channel below Kaukauna 5th lock	Left side of channel below Kaukauna 5th lock on existing dredge banks.	United States & State of Wisconsin	75' × 1000'	10.6 years
Channel below Little Chute Combined Locks	Left side of channel below Little Chute Combined Locks.	United States & State of Wisconsin	50' × 400'	8.8 years
Channel above Little Kaukauna lock	Left side of channel above Little Kaukauna lock on existing dredge bank.	United States	50' × 300'	8.8 years

Table 1.5. List of Anticipated Dredging Sites and Other Related Data

Areas Requiring Maintenance Dredging	Location of Proposed Disposal Areas	Owner of Proposed Disposal Area	Principal Preparatory Work Required to Make Available	Est. Quantity of Material to be Removed	Est. Total Time for Dredging
Canals above and below DePere Lock (5)[a]	Wells Coal and Dock Property, right bank of channel	City of DePere	Agreement with City of DePere for distribution of dredging materials on future park site.	2,000 yd	7 days
Canals above and below Little Kaukauna Lock (3)[a]	Acquire disposal rights to fill in headrace area above abandoned paper mill	United States & private	Dike and riprap river side of headrace area.	1,500 yd	5 days
Canals above and below Rapide Croche Lock (3)[a]	Right canal bank above and below lock	United States & Kaukauna Utilities	Acquire disposal rights, dike & riprap river side and downstream end of area.	900 yd	3 days
Below the Kaukauna 5th lock and in the canals between the Guard Lock and the 1st lock at Kaukauna (5)[a]	On and along left canal bank between 4th and 5th locks	United States & private	Acquire 2.3 acres of adjacent vacant property and divert overflow ditch to canal below 4th lock.	7,000 yd	25 days
Below the Little Chute Combined Locks (4)[a]	Right canal bank between Combined Locks Dam and Combined Locks	U. S. & Combined Locks Paper Co.	Acquire disposal rights. Dike and riprap river side to above tailwater level.	2,000 yd	7 days
	Right canal bank adjacent to Little Chute 2nd lock	U. S. & City of Little Chute	Agreement with City of Little Chute for distribution of dredging materials on municipal landfill area.		
Canals above and below Cedars Lock, and channel at Sunset (Drunkard's) Point	Right canal bank to 500 ft below lock	United States & Kaukauna Utilities	Acquire disposal rights. Dike & riprap river side and downstream end of area.	2,000 yd	7 days
Below the Appleton 4th lock (3)[a]	Currently unspecified location[b]		Agreement with City of Appleton to accept and distribute dredging materials.	1,400 yd	4 days
Above and below the Appleton 1st, 2nd, & 3rd locks and in the Grignon Rapids channel (4) & (5)[a]	Currently unspecified location[b]		Agreement with City of Appleton to accept and distribute dredging materials.	2,000 yd	7 days

Table 1.5. Continued

Areas Requiring Maintenance Dredging	Location of Proposed Disposal Areas	Owner of Proposed Disposal Area	Principal Preparatory Work Required to Make Available	Est. Quantity of Material to be Removed	Est. Total Time for Dredging
Menasha Channel below lock (3)[a]	Currently unspecified location[b]		Agreement with City of Menasha to accept and distribute the dredging materials.	4,500 yd	15 days
Neenah Channel (5)[a]	Doty Park, left bank of channel	City of Neenah	Agreement with City of Neenah to accept and distribute the dredging materials.	2,000 yd	7 days
Calumet Harbor (4)[a]	Lawn area, Columbia Park	Fond du Lac County	Agreement with Fond du Lac County to accept and distribute the dredging materials.	9,000 yd	30 days
	Left bank of Pipe Creek east of Columbia Park between E-W road to the Village of Pipe and creek	Private	Contract with landowners for distribution of dredging materials on agricultural lands.		
Brothertown Harbor (4)[a]	Northwest of basin, west of Mill Creek	Private & United States	Contract with landowners for distribution of dredging materials on agricultural lands.	3,000 yd	10 days
Stockbridge Harbor (4)[a]	Northeast bank of basin, west of access road	Private & United States	Contract with landowners for distribution of dredging materials on agricultural lands.	2,000 yd	7 days
Fond du Lac Harbor (3)[a]	Left bank of channel	City of Fond du Lac	Agreement with City of Fond du Lac to accept and distribute the dredging materials.	20,000 yd	50 days
Channel in Big Lake Butte des Morts below junction of Upper Fox and Wolf River (5)[a]	Currently unspecified location[b]			15,000 yd	40 days
Wolf River (Boom Cut) (4)[a]	Currently unspecified location[b]			25,000 yd	65 days
Wolf River from Fremont to New London (4)[a]	Agricultural lands along river	Various private owners	Contract with landowners for distribution of dredging materials on agricultural lands.	7,000 yd	25 days

[a] *Number in parentheses indicates frequency of dredging. For example (5) indicates dredging at a five-year interval.*

[b] *Dredging subject to availability of Federally and State approved disposal site.*

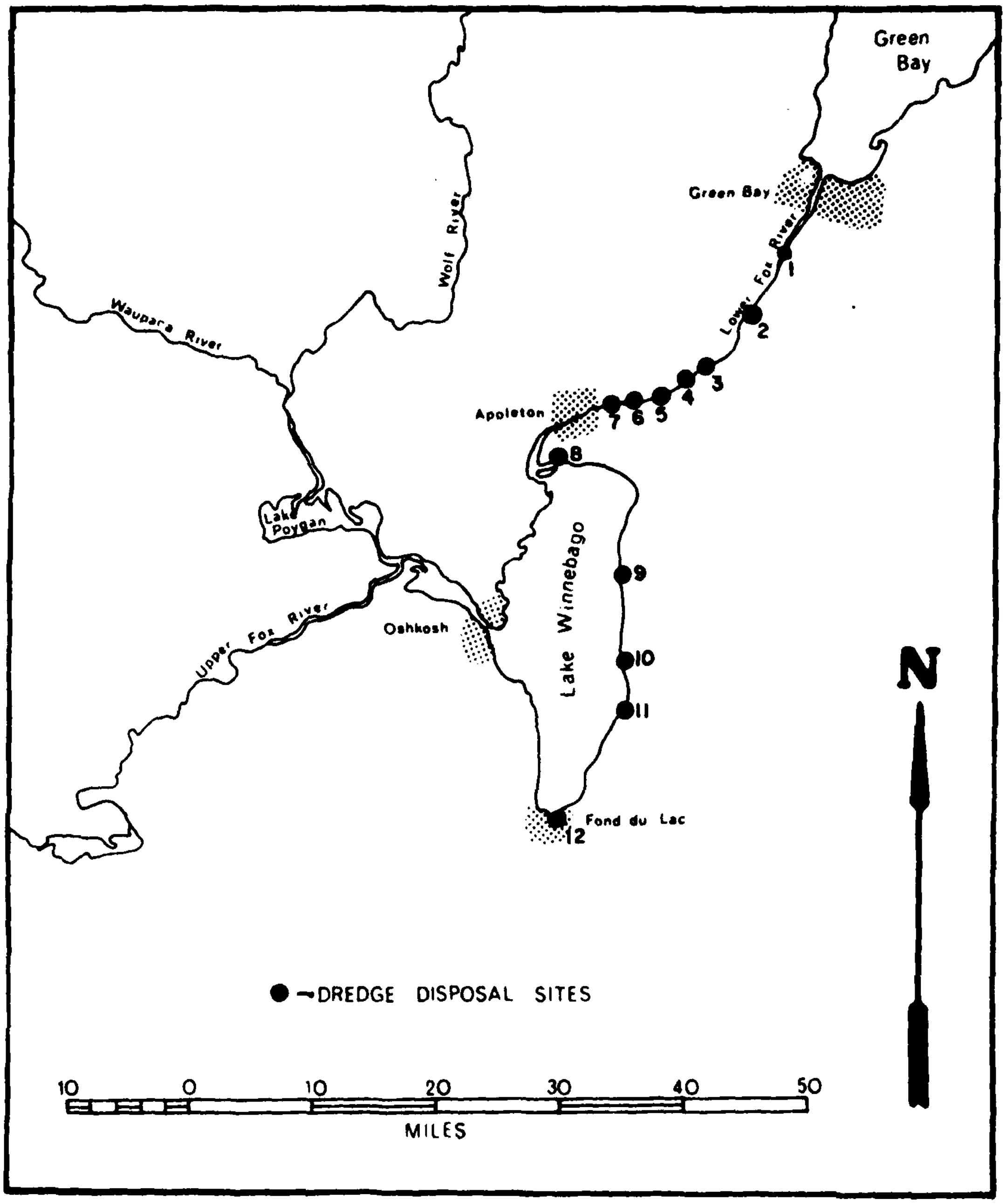


Fig. 1.4. Vicinity Map of Project Dredge Disposal Sites

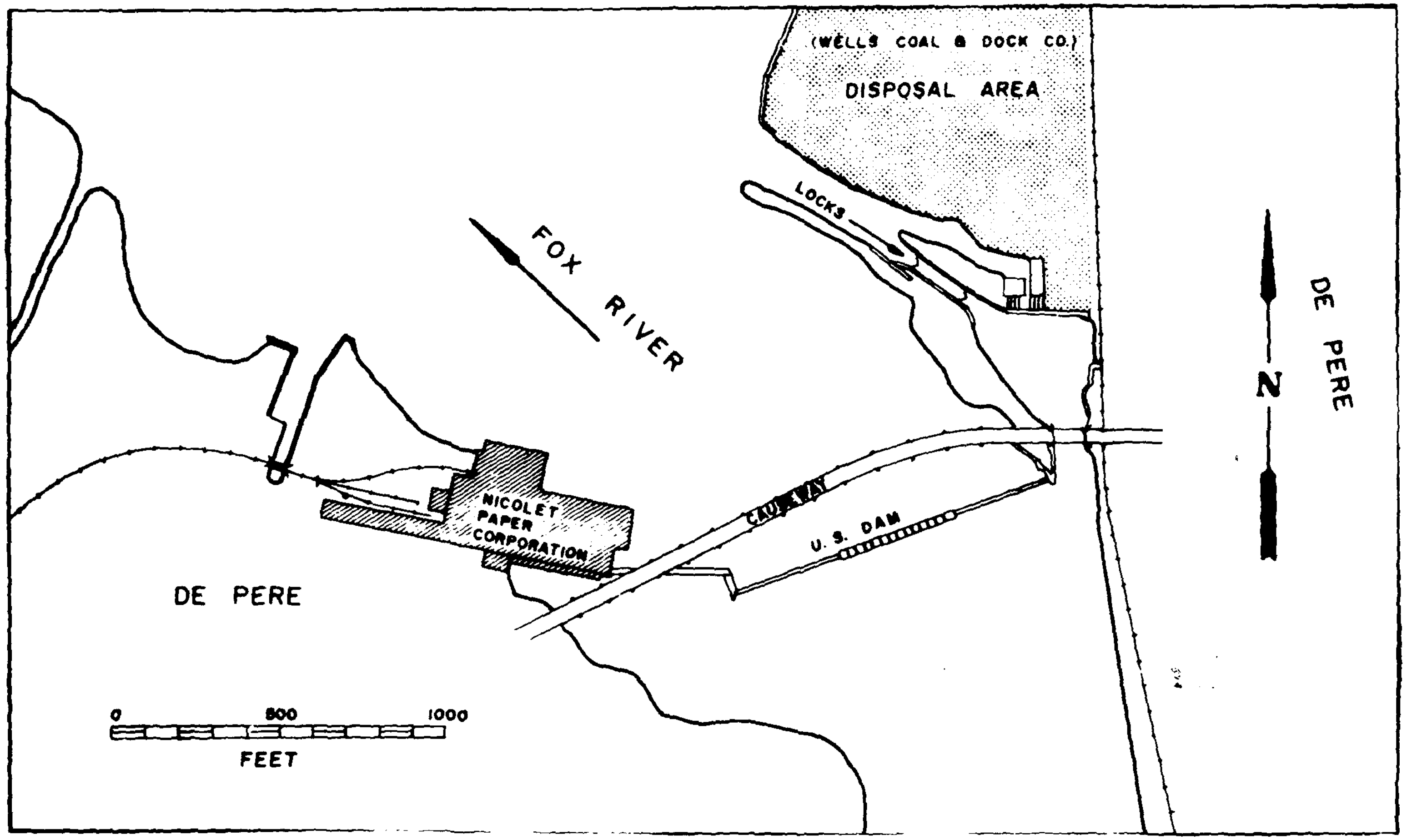


Fig. 1.5. Wells Coal and Dock Property Disposal Area

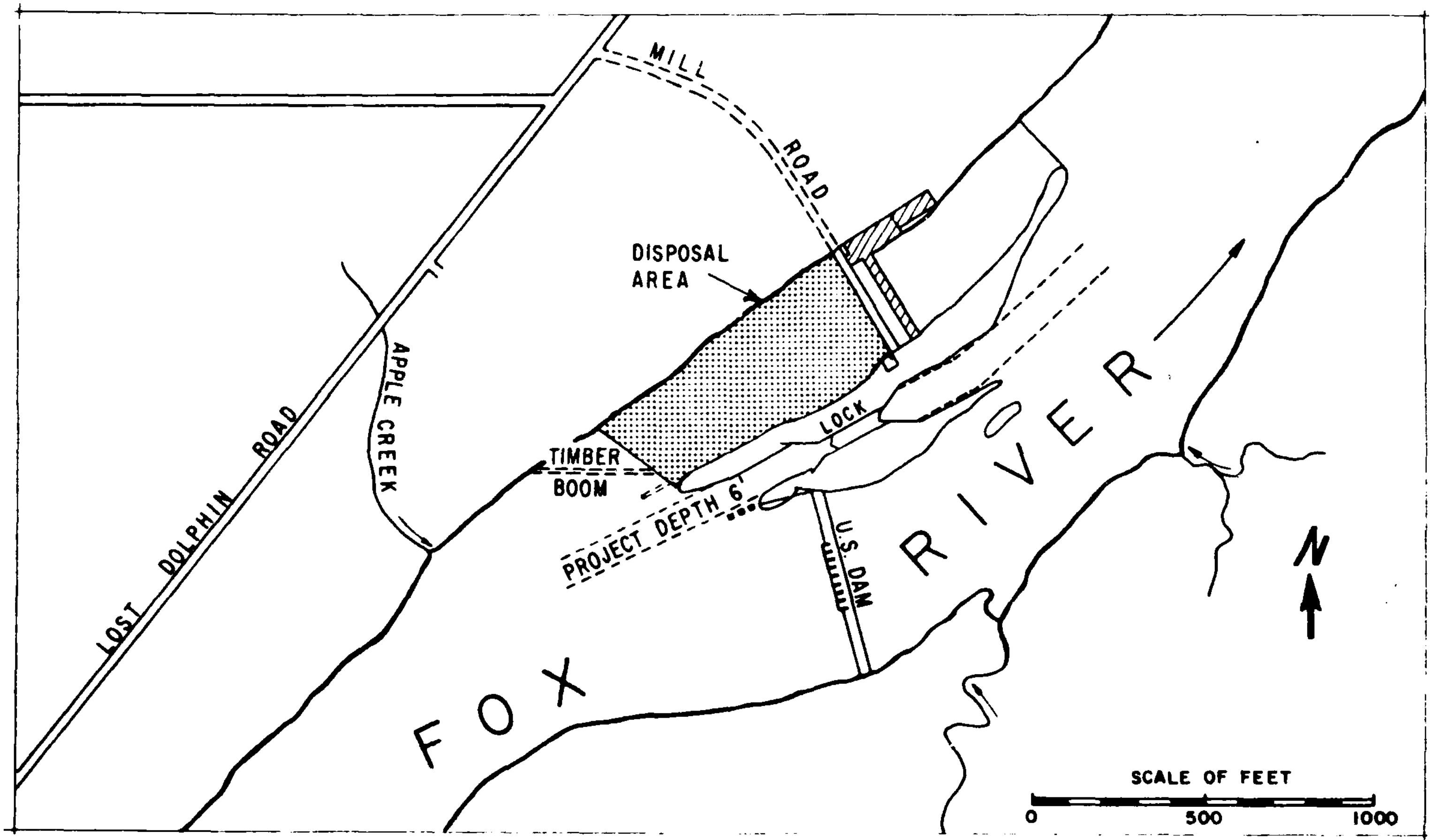


Fig. 1.6. Little Kaukauna Headrace Disposal Area

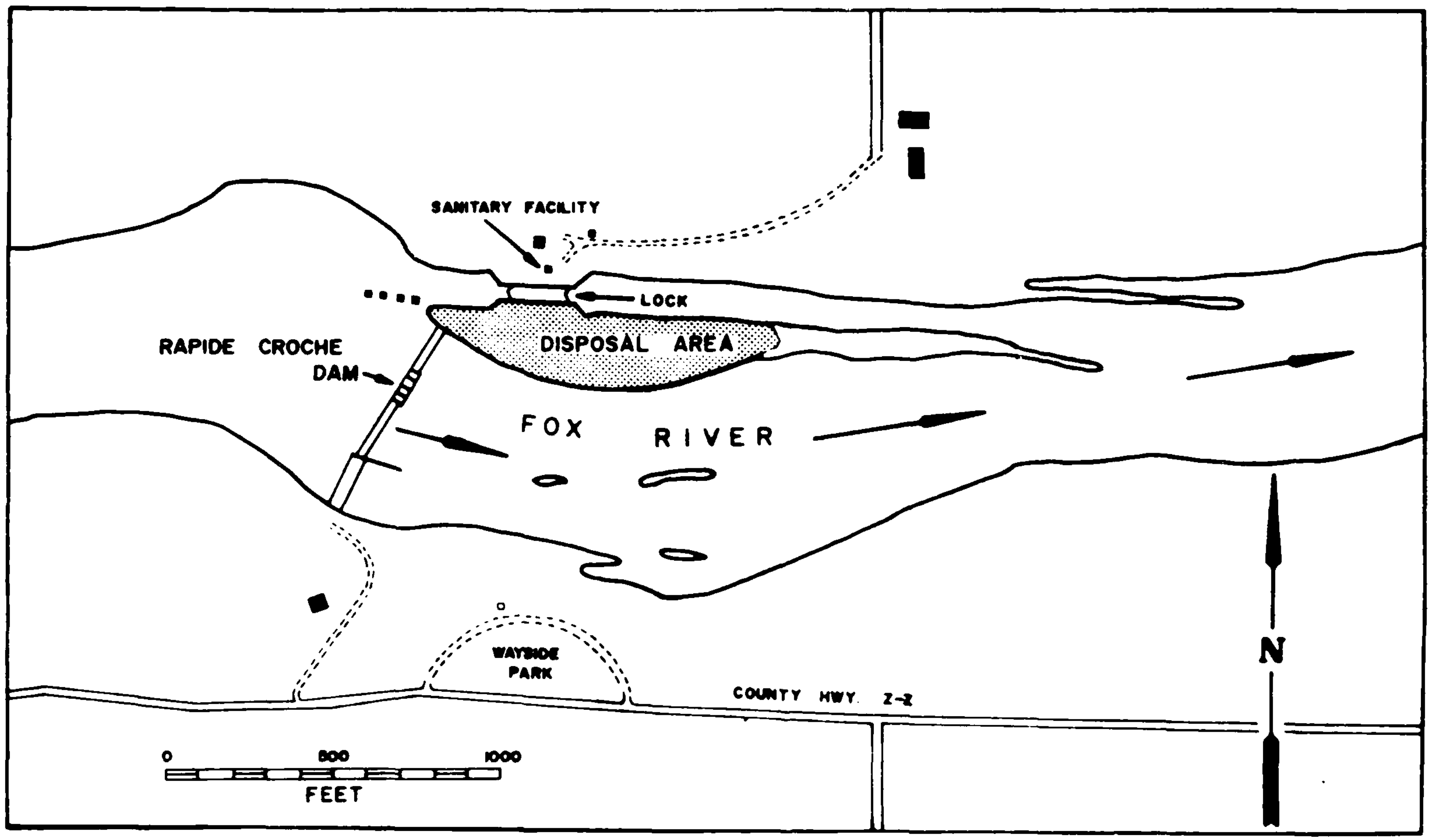


Fig. 1.7. Rapide Croche Canal Bank Disposal Area

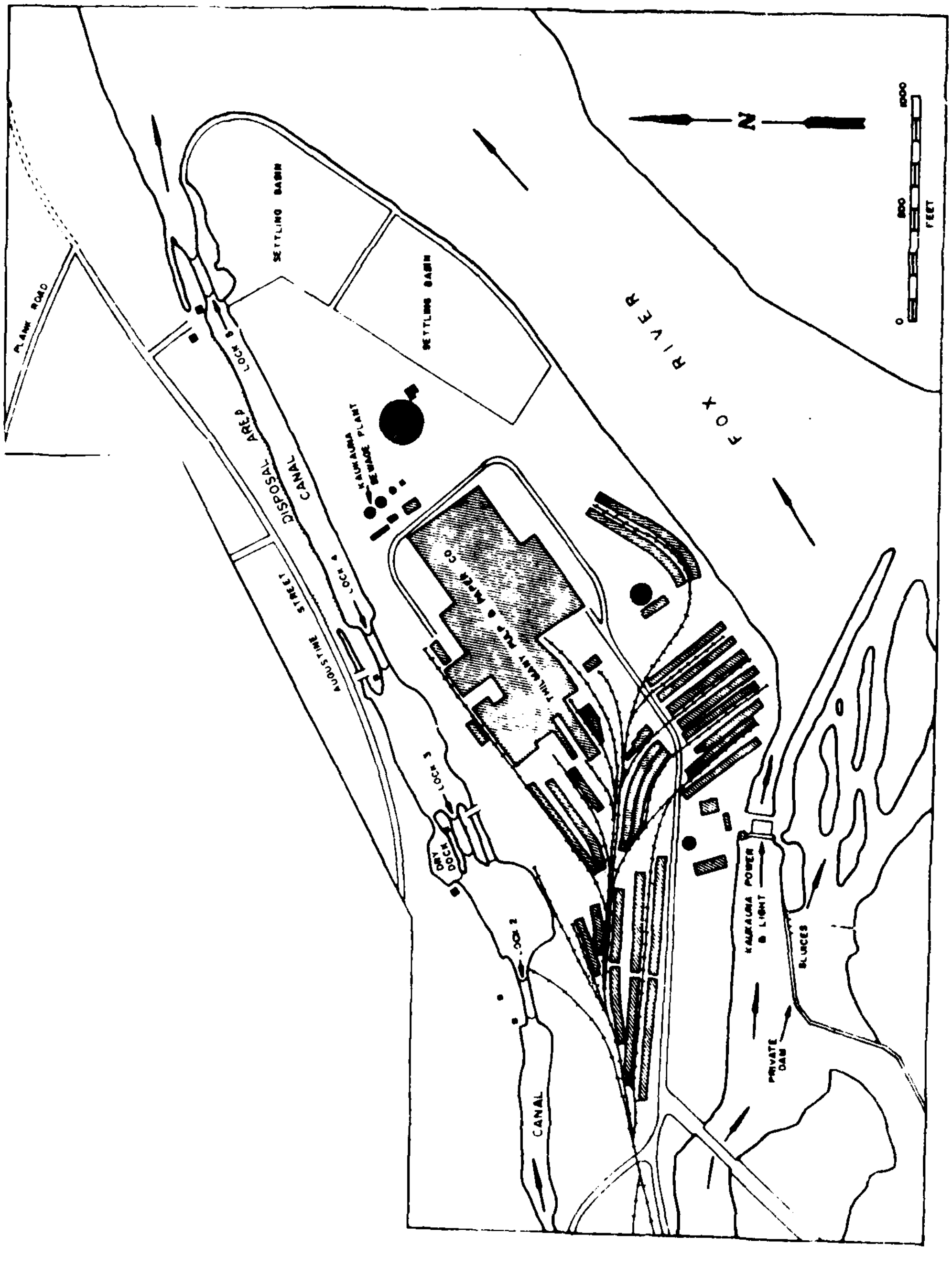


Fig. 1.8. Kaukauna Canal Bank Disposal Area

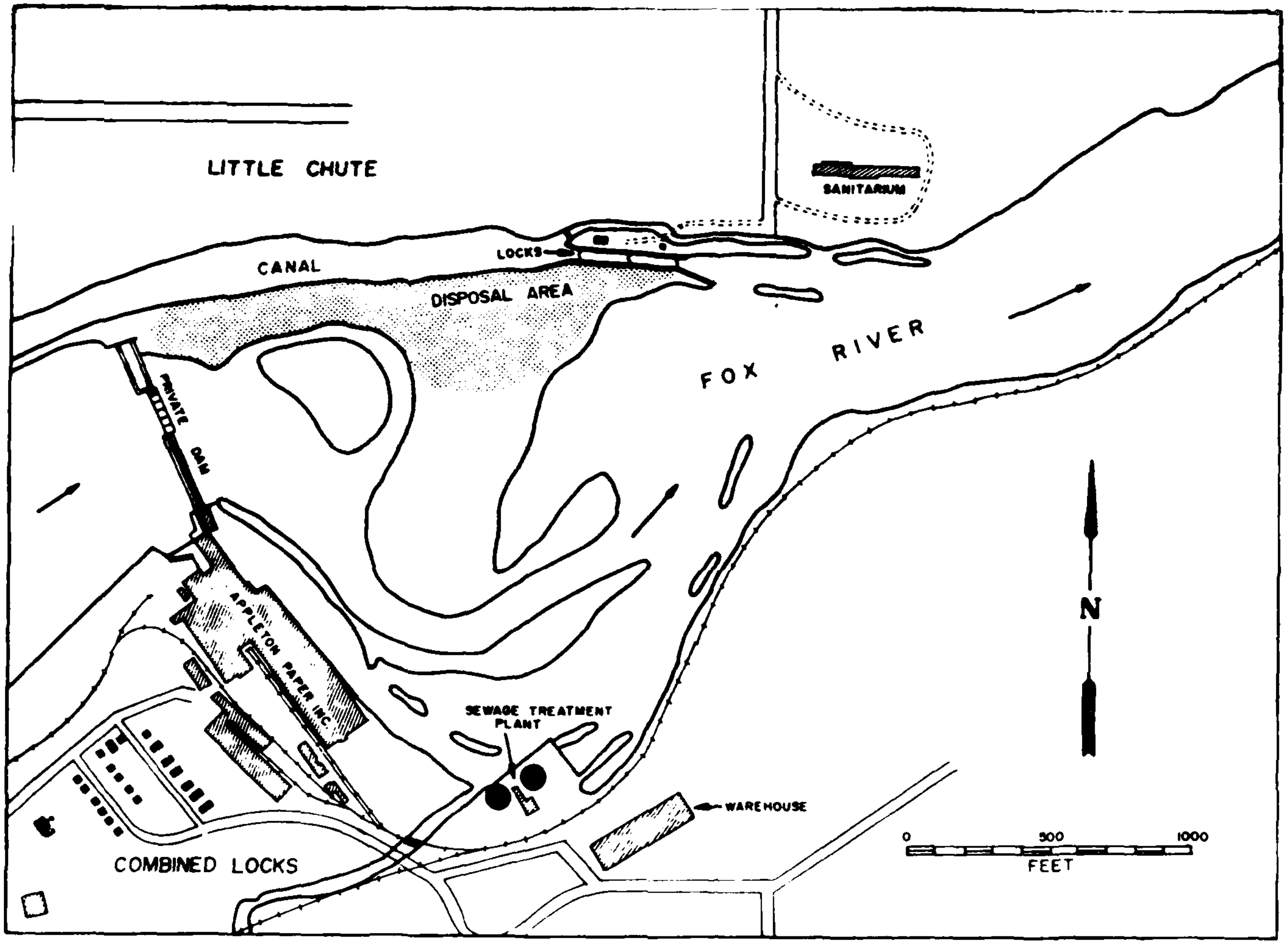


Fig. 1.9. Disposal Area Below Combined Locks Dam

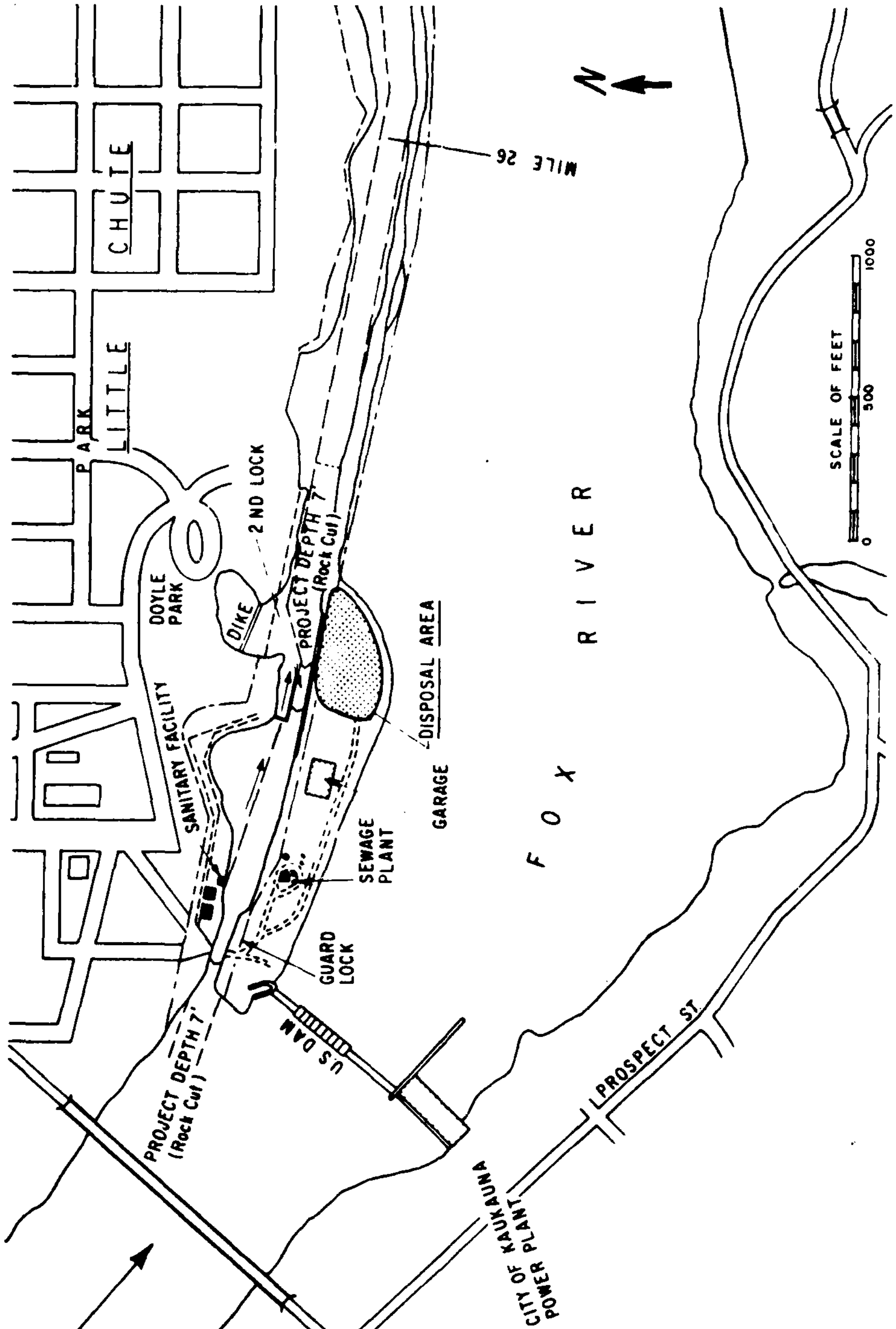


Fig. 1.10. Disposal Area Adjacent Little Chute and Lock

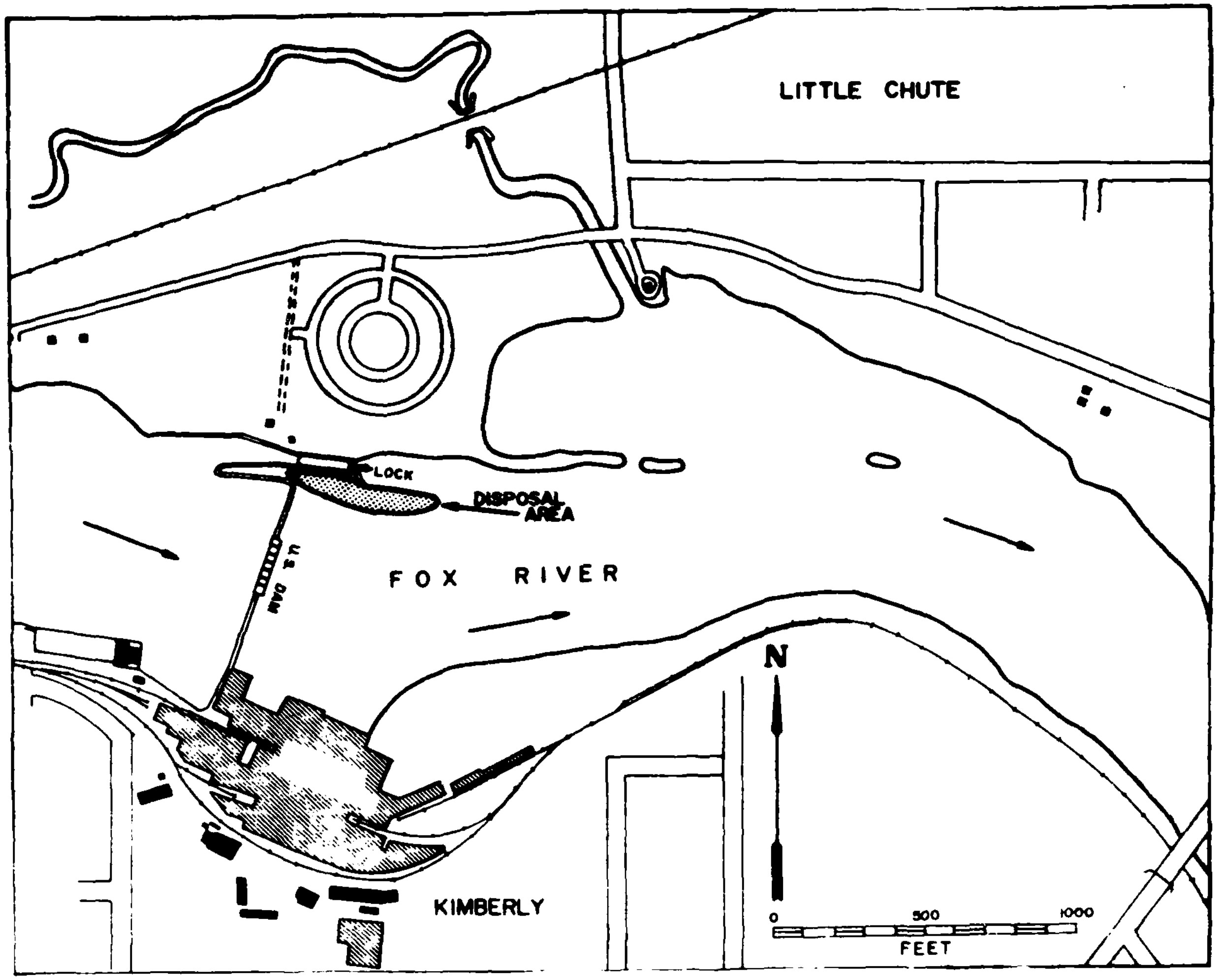


Fig. 1.11. Cedars Lock Canal Bank Disposal Area

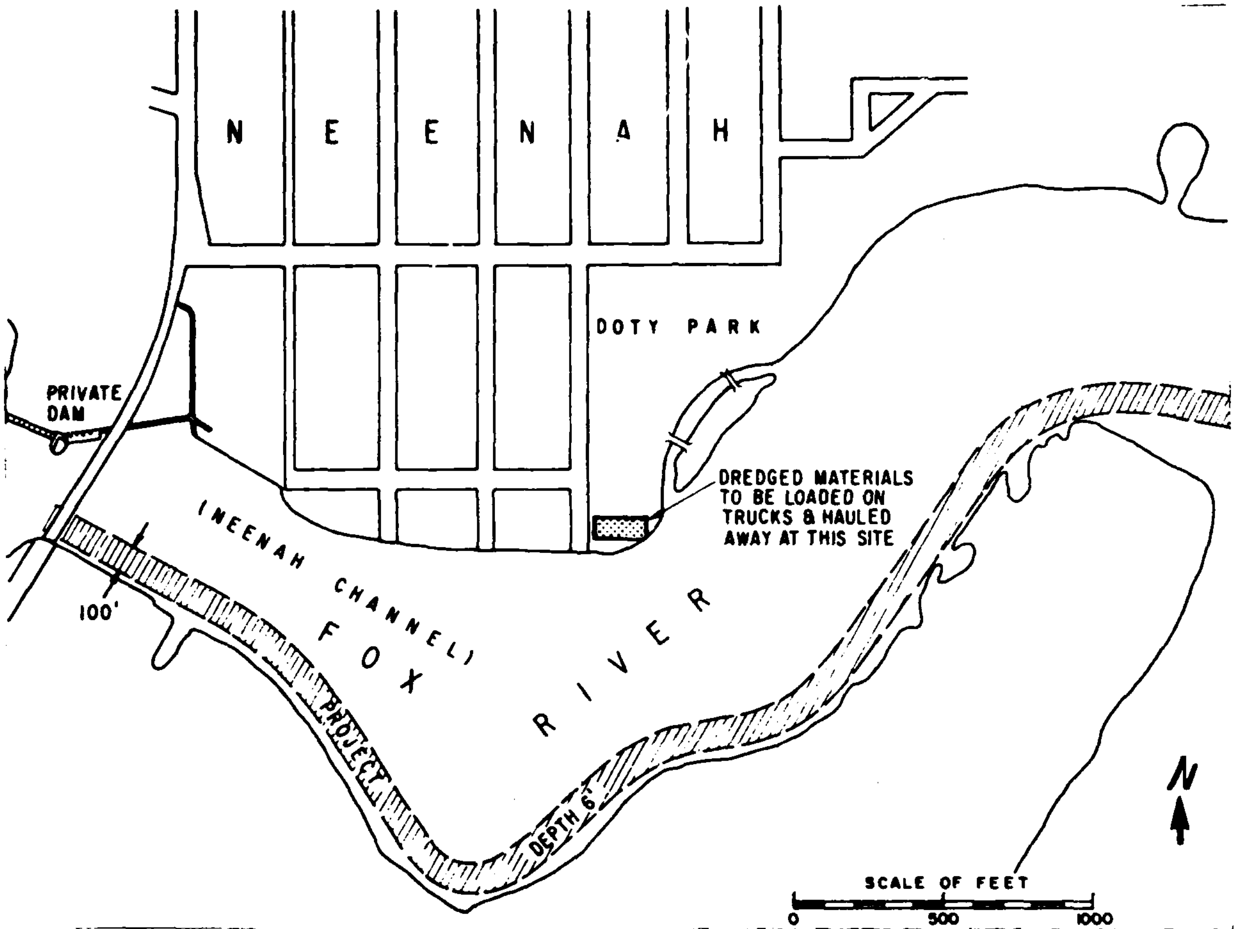


Fig. 1.12. Doty Park Storage Site

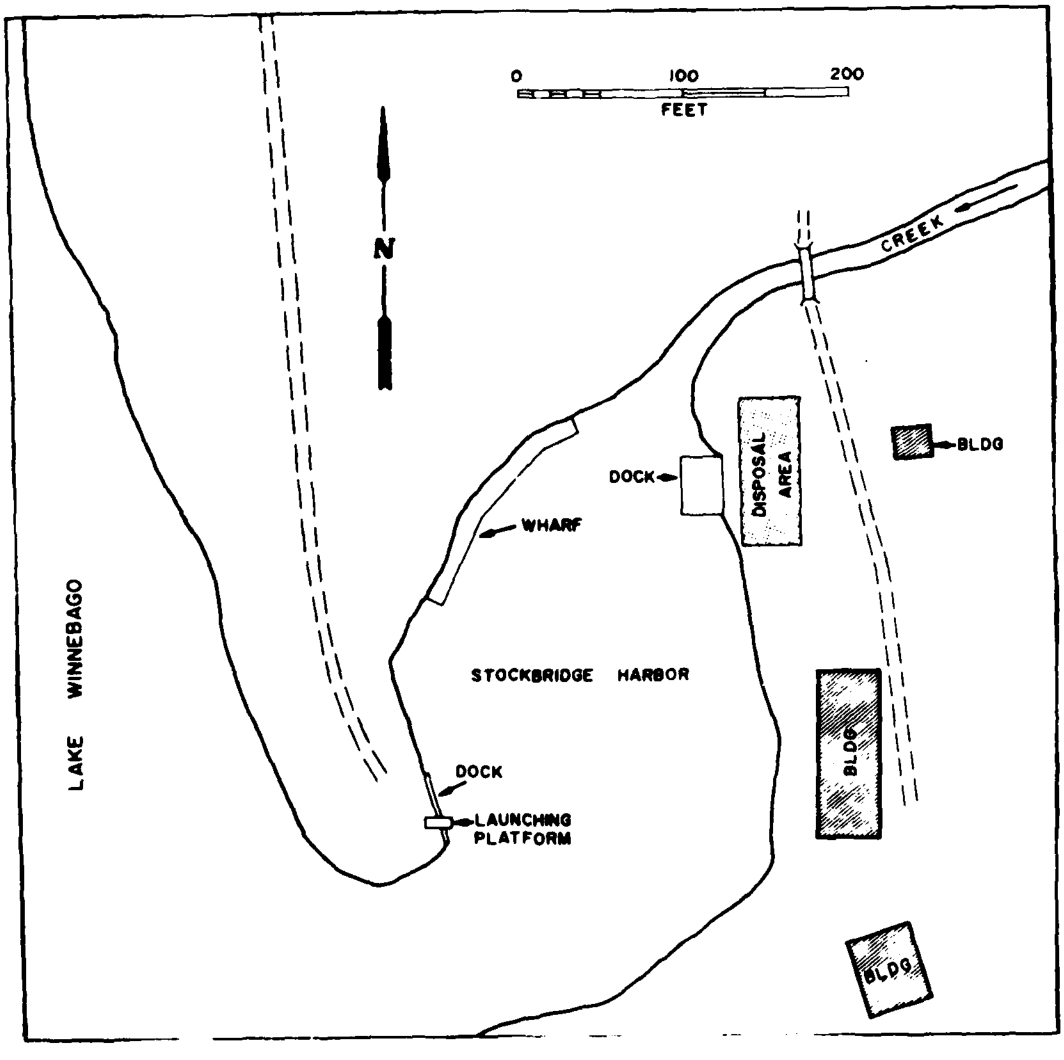


Fig. 1.13. Stockbridge Harbor Storage Site

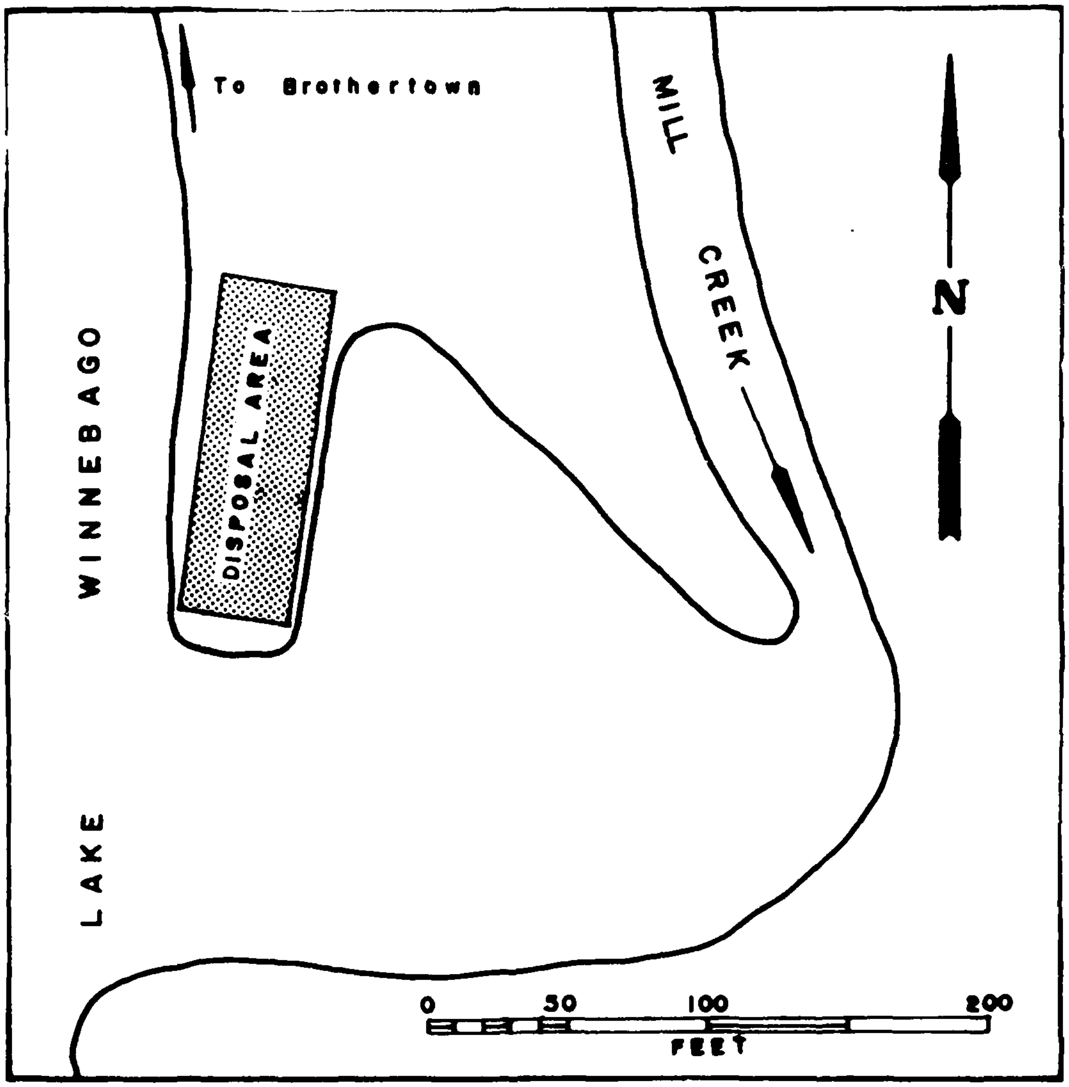


Fig. 1.14. Brothertown Harbor Storage Site

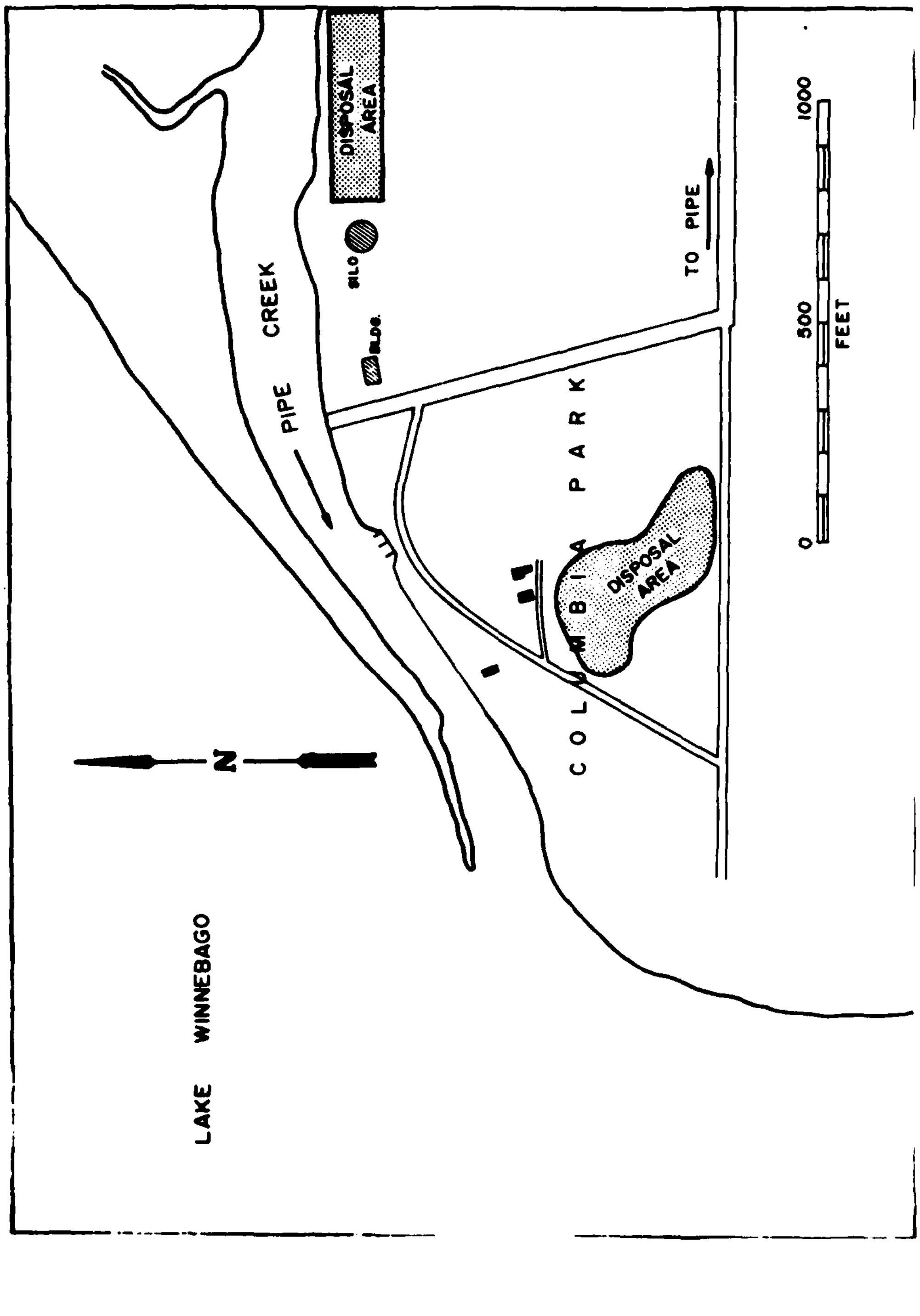


Fig. 1.1[illegible]. Columbia Park Disposal Area

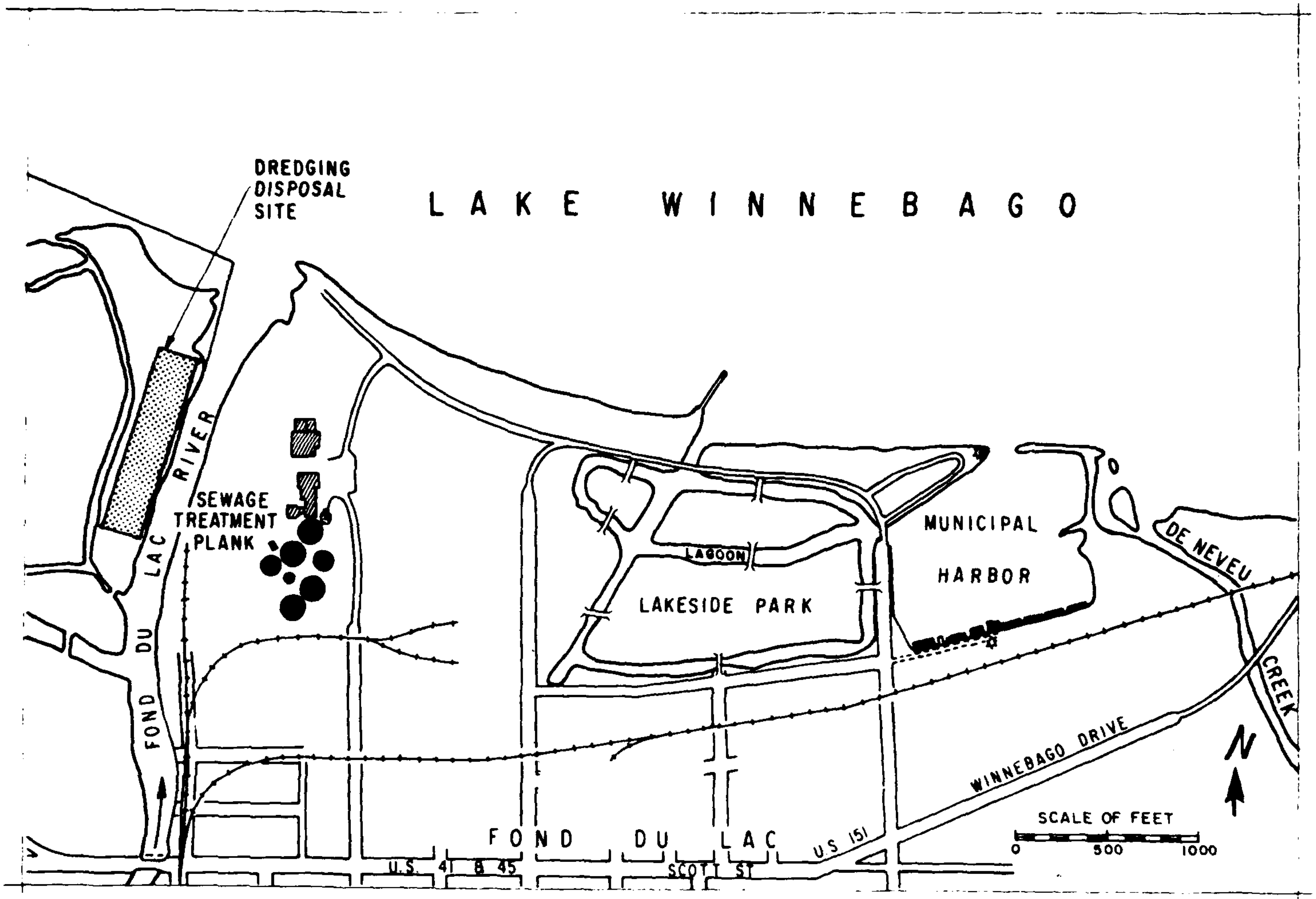


Fig. 1.16. Fond du Lac Disposal Area

1.30
Harbors of Refuge - Federally improved harbors of refuge on Lake Winnebago are located at Stockbridge, Brothertown, Calumet, and Fond du Lac (see Appendix A). There are also several non-Federal harbors on Lake Winnebago, including High Cliff State Park, Millers Bay, and a municipal harbor at Fond du Lac. Several natural harbors for shallow draft craft are also available, such as in the outlet channels at Menasha and Neenah and in the inlet channel of Millers Bay at Oshkosh. Large numbers of recreational craft using Lake Winnebago need protective harbors during sudden bad weather and these harbors on the lake offer such refuge benefits. Continued maintenance of small harbors on Lake Winnebago will provide for the safety of the hundreds of small boats using that lake for recreation, including boating, sport fishing, water skiing and swimming. These small harbors also provide safe launching sites and harbors of refuge for the large numbers of trailer-hauled boats brought to and used on these waters from a wide tributary area covering the eastern half of Wisconsin, as well as northern Illinois and Indiana. Although U. S. Coast Guard statistics are not available for recreational boating accidents on Lake Winnebago, it is presumed that many storm-induced swamping accidents have been prevented by the presence of these harbors.

1.31
Lands - The United States owns land at each of the lock sites and Federal improvements along the Fox River, as well as at two harbors on Lake Winnebago. These lands, totaling about 94 acres (see Table 1.6), exclusive of water areas involved in canals and harbor basins, are needed to permit access to the structures for necessary construction and maintenance operations. In general, the lands owned are adequate for project maintenance and operation, with the exception of adequate land disposal sites for dredged materials.

Flow Regulation on Fox River System

1.32
The flow of the Lower Fox River is affected by the control of storage in the Lake Winnebago Pool, as authorized by the existing project and various special acts. This regulation is of such importance to municipal, industrial, hydropower, navigation, and general riparian interests along the river, and around the lake, that Congress has enacted several special acts to require and set limits for regulation.

1.33
A brief history and background concerning regulation of Lake Winnebago is contained in Appendix C. A detailed history of this subject is contained in Appendix B, House Document No. 146, 67th Congress, 2d session, on Fox River, Wisconsin. The water level of the Lake Winnebago pool is regulated to the extent possible in accordance with these laws and related directives in the interest of navigation on the Lower Fox River, to preserve the private rights to the use of water not needed for navigation for power development, and to reduce flood damages. The Winnebago pool includes Lake Winnebago, Lake Poygan, Lake Butte des Morts and several smaller lakes. The total surface area of the bodies of water

Table 1.6. United States Property for Fox River Improvement

Site	Acreage Owned	Principal Improvements
De Pere Lock and Dam	2.039	Lock, dam, dwelling
Little Kaukauna Lock and Dam	3.24	Lock, dam, dwelling
Rapide Croche Lock and Dam	9.70	Lock, dam, dwelling
Kaukauna Locks and Dam	27.94	5 locks, guard lock, dam, area office, 2 dwellings, dry dock, warehouse, plant repair yard, canals
Little Chute Locks and Dam	16.61	3 locks, guard lock, dam, canals, 2 dwellings
Cedars Lock and Dam	2.88	Lock, dam, dwelling
Appleton Locks and Dams	16.796	4 locks, 2 dams, 2 dwellings, canals
Menasha Lock and Dam	13.64	Lock, dam, dwelling, canal
Stockbridge Harbor	1.27	Entrance channel and 1.0-acre basin
Brothertown Harbor	0.20	Entrance channel and 0.5-acre basin

is about 265 square miles. The water level of this large reservoir system is controlled by the Neenah and Menasha Dams. Except for extremes of very high or very low water, the level of the lake has been operated so that the range of fluctuations between high and low water is rarely more than about 30 inches. The operational range on Lake Winnebago is restricted during the navigation season from 21-1/4 inches above the crest of Menasha dam down to the crest of the dam. During the closed season from about 1 November to 1 May the lake level may be drawn down to 18 inches below the crest of the Menasha dam with provision, as noted above, that the level be back at dam crest by opening of the navigation season. These limitations are established by law and are not administrative determinations by the Corps of Engineers.

1.34
The drawdown schedule of the pool begins about 1 November of each year when the water level at the Menasha Dam normally stands at a few inches above crest. Drawdown starts with a gradual lowering of the lake level which continues into February. The rate of drawdown is related to precipitation and other conditions. In late February to early March, water levels are again raised. Sluicing is heavy during the early spring. By spring ice break-up time, the water level of the Winnebago pool is usually several inches below the crest at Menasha dam, thus allowing for floodwater storage. The lowered water levels at ice break-up time prevents extensive damage from ice build-up and its associated damage to the shoreline properties. The spring runoff normally restores the pool level to several inches above the crest of the Menasha dam. During late spring and summer months, releases are made to provide a steady flow for power generation, stream sanitation, and recreation craft.

ANNUAL OPERATIONS AND MAINTENANCE COSTS

1.35
All completed features of the existing project were constructed between 50 to 90 years ago and the investment in such improvements is considered to have been fully amortized by past benefits. The cost of the Fox River waterway improvement to 30 June 1976 was $24,064,600, of which $3,753,000 was for new work and $20,311,600 was for operation and maintenance.

1.35
Table 1.7 gives the cost of the project by year for the last ten years. The chief costs are those associated with operation of the locks and dams. The most costly single item in the operation of the locks and dams is the salary of the lockmasters who operate the many locks and dams along the lower waterway. There are 13 lockmasters, three of which are seasonal working only during the six-month navigation season.

1.37
A cost summarization is presented in Table 1.8. The average annual operation and maintenance cost over the five year period, 1971 - 1975, inclusive, was $742,400. The major portion, $301,100 or 40 percent was spent for dam operation and maintenance, while $243,500 or 33 percent, was used for operation and maintenance of the lock system. On the

average, $15,300 or 2 percent was spent for dredging the Wolf River including Boom Bay, and $15,000 or 2 percent was required for engineering studies, supervision, and other miscellaneous project activities.

Table 1.7. Annual Operation and Maintenance Costs for the Fox River, Wisconsin Project, 1966-1975

	1975	1974	1973	1972	1971	1970	1969	1968	1967	1966
OPERATION										
Regulation of Lake Winnebago, condition and operation studies, and related activities	139,983	93,293	51,860	24,226	36,856	46,128	64,526	29,636	30,504	33,403
Operation of locks	127,162	129,813	89,909	87,912	84,673	79,468	80,154	88,505	72,351	75,615
Operation of dams	270,219	265,901	206,144	194,315	184,351	159,536	140,573	176,983	138,449	145,647
Supervision and administration	30,210	23,457	4,685	66,230	65,652	58,577	51,060	14,682	24,443	-4,859
Total operations cost	567,574	512,464	352,602	368,046	371,732	343,749	336,313	290,687	235,293	249,806
MAINTENANCE										
Locks	76,399	136,141	97,010	40,533	55,148	28,263	40,589	13,793	77,720	45,662
Dams	162,348	103,493	67,230	49,087	2,501		5,301	45,185	47,480	
Channels (including dredging from DePere to mouth of Wolf River), etc.	71,143	95,056	50,255	40,914	35,335	19,226	23,665	23,004	21,938	16,263
Dredging Wolf River (Boom Bay)				30,987		24,047	28,002	14,208	17,033	
Dredging and snagging in Wolf River above Boom Bay				22,865	22,507				10,929	
Dredging Fond du Lac Harbor		37,245				71,831				
Dredging Brotherton Harbor					8,933			1,667	8,401	
Dredging Stockbridge Harbor					7,419			801	3,642	1
Dredging Calumet Harbor					21,465					2
Engineering, supervision and maintenance	162,219	20,481	25,792	54,416	41,072	43,819	21,016	24,986	39,372	14,610
Total maintenance cost	472,109	393,316	240,257	238,802	194,680	182,547	118,573	123,644	226,515	76,532
TOTAL MAINTENANCE AND OPERATION	1,039,683	905,780	592,859	607,785	565,985	526,198	454,886	414,331	461,808	326,338

Table 1.8. Summary of Annual Operation and Maintenance Costs for the Fox River, Wisconsin Project, 1971-1975

	Year					Average of 5 Years
	1975	1974	1973	1972	1971	
Locks and related activities[a]	274,704	361,010	237,174	169,359	175,156	243,481
Dams, operation and maintenance	432,567	369,394	273,374	243,402	186,852	301,117
Wolf River including Boom Bay	0	0	0	53,852	22,807	15,332
Dredging of harbors on Lake Winnebago	0	37,245	0	0	37,817	15,012
Other[b]	332,412	173,751	82,337	144,872	143,780	175,430
Percent of total cost which goes for direct navigation O&M	26	39	40	27	30	33
Percent of total cost which goes for direct dam O&M	42	40	46	40	33	40
Percent of total cost which goes for the Wolf River including Boom Bay	0	0	0	9	4	2
Percent of total cost which goes for dredging of harbors on Lake Winnebago	0	4	0	0	7	2

[a] *Includes lock operation and maintenance, and associated channel maintenance.*

[b] *Includes condition and operation surveys, discharge observations and gauging, engineering and hydraulic studies, supervision and administration, and other miscellaneous activities.*

SECTION 2

ENVIRONMENTAL SETTING

NATURAL ENVIRONMENTAL ELEMENTS

Physiographic Features

2.01
The Wolf-Fox River Basin, located in east central Wisconsin (see Fig. 2.1), includes 4,086,451 acres (6,385 square miles) and is a subsection of the Great Lakes-St. Lawrence River continental drainage basin.[1] Although the basin contains all or part of 20 Wisconsin counties, all but eight drain into watersheds which enter the project area upstream of the Fox River Navigation Project and/or have drainage inputs which enter the project area as point source inputs (see Fig. 2.2). The description and discussion of the Fox River, Wisconsin Navigation Project area in this document is, therefore, limited to the area of the basin shown in Figure 2.2. This portion of the basin forms the immediate environs of the project area (see Fig. 2.3). By limiting the discussion and description to this smaller area, the amount of extraneous details contained in this statement has been greatly reduced without sacrificing important details or overlooking any impacts and effects of the project.

2.02
For descriptive purposes, the project area can be considered to be three connected but quite distinct physiographic regions (see Fig. 2.3). These are: (1) the region containing the Wolf River between New London and Lake Poygan (the river's mouth is at Lake Butte des Morts); (2) the region containing Lakes Poygan, Winneconne, Butte des Morts, and Winnebago from the mouth of the Wolf River in Lake Poygan to the Neenah and Menasha dams, collectively known as the Winnebago Pool; and (3) the region containing the Lower Fox River from the Neenah and Menasha dams to immediately downstream of the navigation lock at De Pere.

2.03
The Wolf River region of the project area has smooth, marshy plains surrounded by agricultural land and is located within the Wisconsin counties of Waupaca, Waushara, and Winnebago.[2] At New London, 56.5 miles above Oshkosh, the Wolf River has a standard low water elevation of 747.6 ft (MSL) and serves as the drainage stream for eight counties which drain into the upper Wolf River and the Embarrass River.[1] These two rivers join just east of the U. S. Highway 45 bridge at New London, which is the upstream limit of the project.[1,3] From New London to Lake Poygan about 25 miles in length measured along the river, the meandering Wolf River intercepts its tributaries Cedar (Crew) Creek, Little Wolf River, and the Waupaca River, in that order.[4] Below New London the normal slope is very flat, averaging about 0.04 foot per mile. Along this reach of

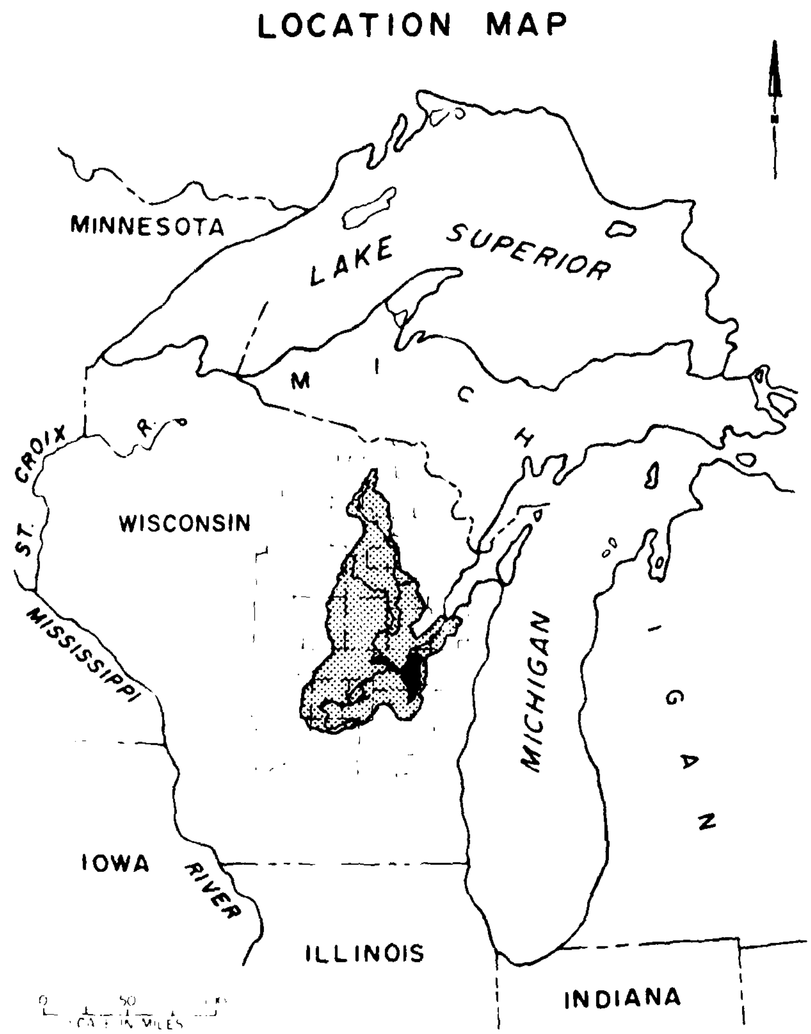


Fig. 2.1. Location of the Wolf-Fox River Drainage Basin.

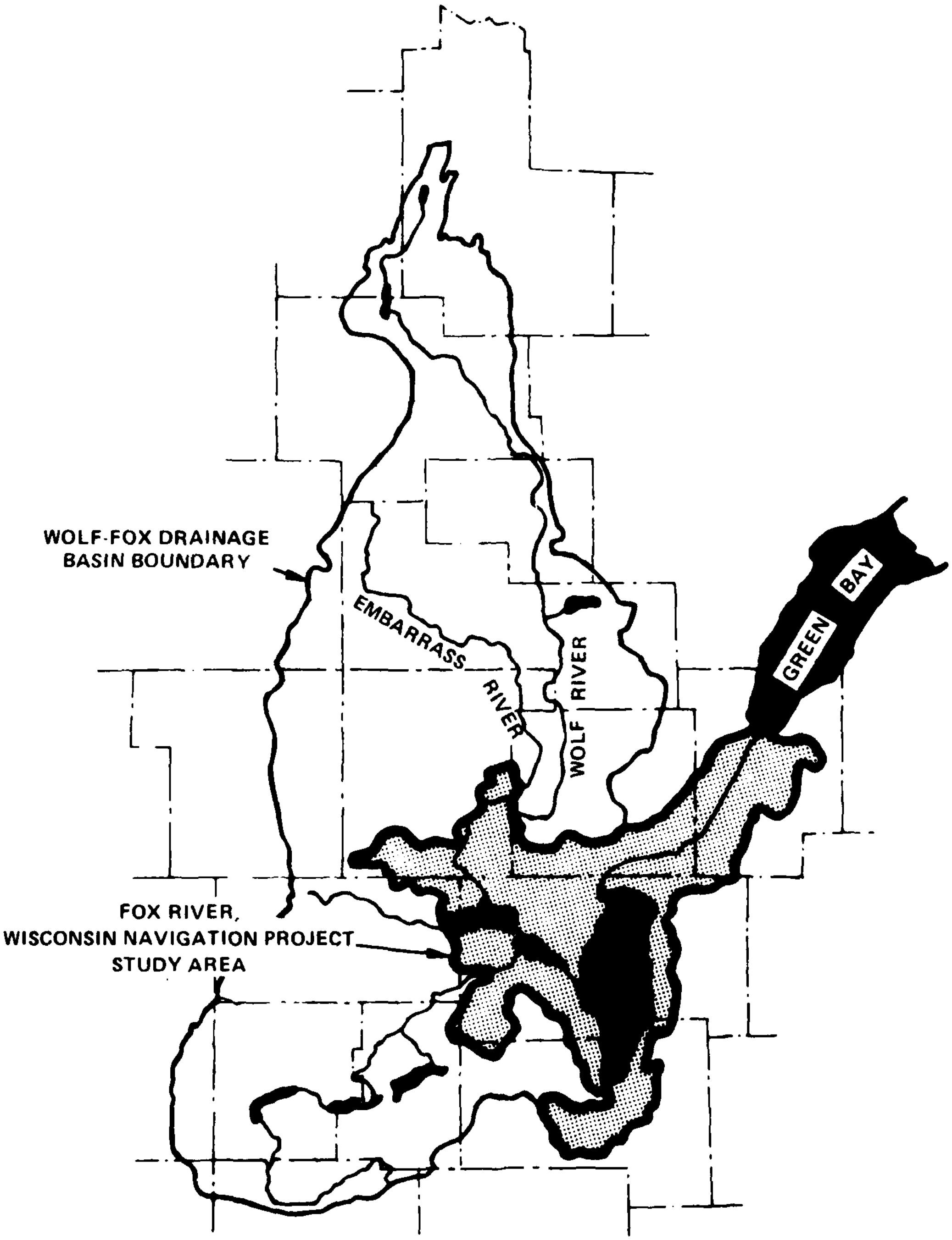


Fig. 2.2. The Wolf-Fox River Basin Showing the Project Study Area.

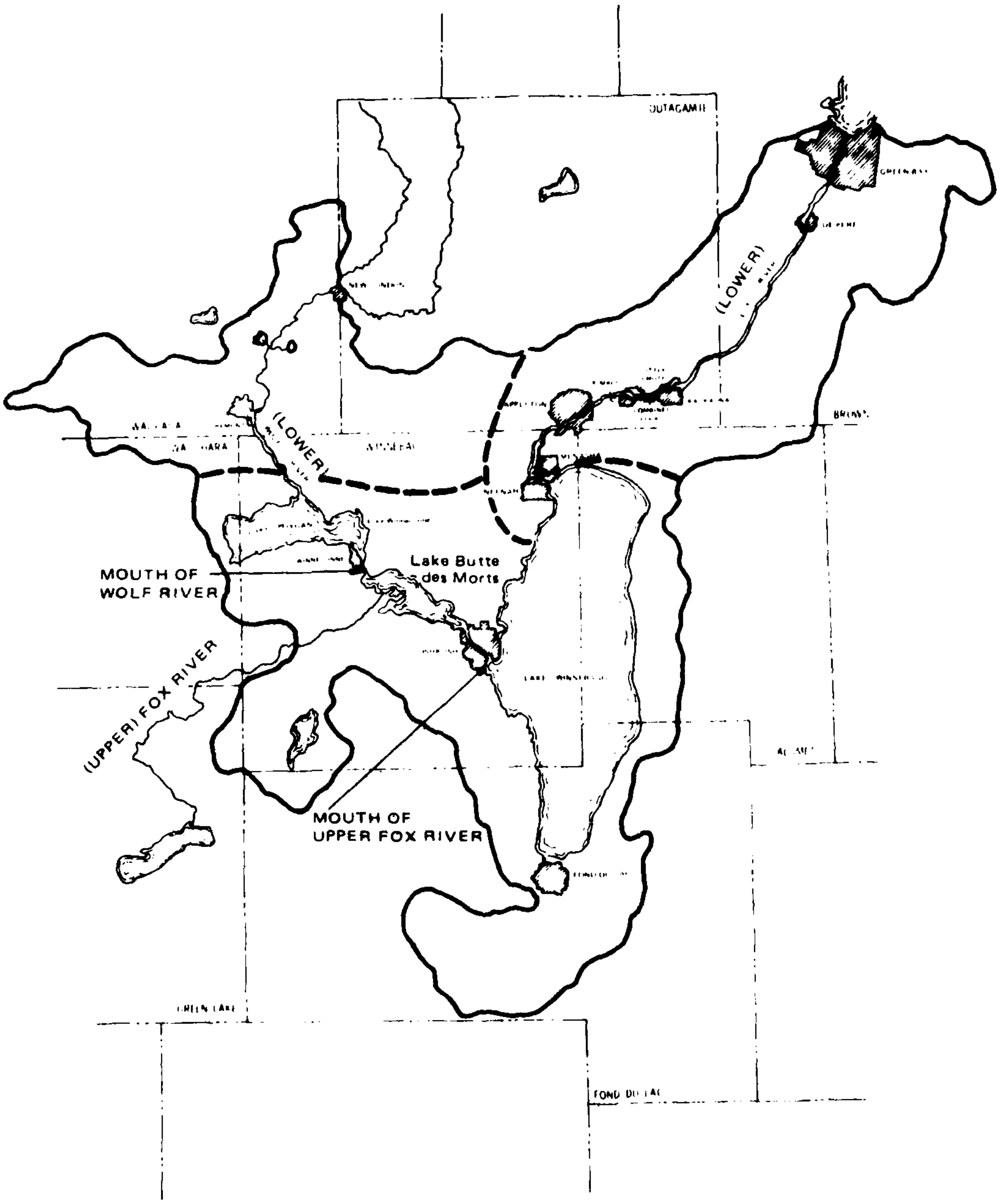


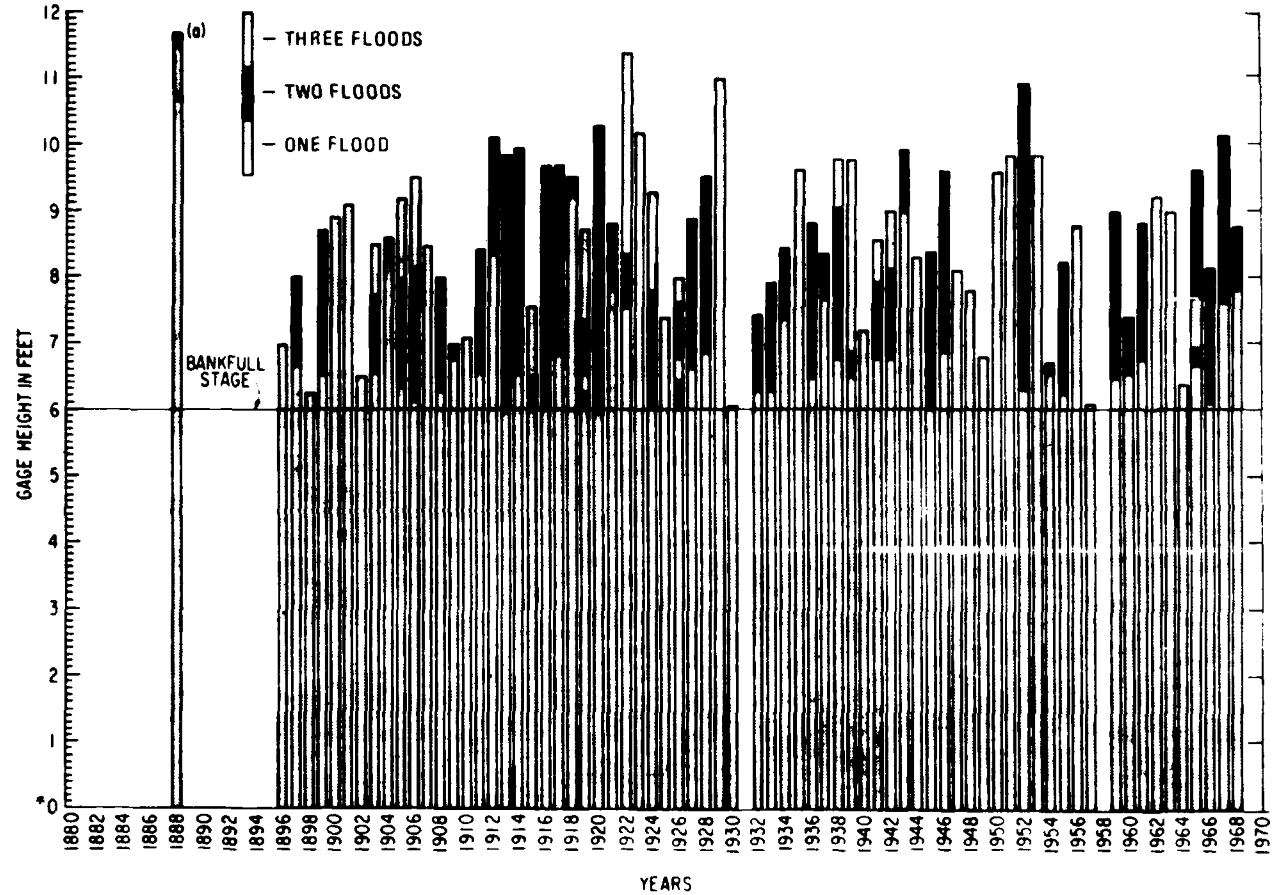
Fig. 2.3. The Fox River, Wisconsin, Project Study Area

about 47 miles the river flows through large marshy areas with generally low banks and varies in width from 200 to about 1,000 feet. Between New London and its mouth, the Wolf River enlarges into five lakes with combined low water areas of about 38 square miles and high water area of about 63 square miles. These small lakes rise and fall with the river and become part of the Lake Winnebago pool at high water stages.

2.04
The drainage area of the Wolf River at New London, Wisconsin, is 2,240 square miles.[4] At its outlet into Lake Butte des Morts, the drainage area is 3,750 square miles. The Wolf River environs are subject to frequent and repeated flooding. A total of 146 floods occurred during the 73-year period of streamflow records discussed in Reference 4. Figure 2.4 (from Ref. 4) is a chart showing floods above bankfull stage. When exceptionally heavy rainfalls with rising temperatures cause rapid snow melt, the combination produces severe flooding.[4] Thus, the floods of most severe magnitude are spring floods.

2.05
The central region of the project area is one of large lakes which are controlled impoundments formed by the dams in the two channels leading to the Lower Fox River at Neenah and Menasha (see Fig. 2.3). This region is contained in six watersheds,[1] one contains Lake Poygan (10,992 acres) and Lake Winneconne (3,264 acres), two drain into Lake Butte des Morts (8,857 acres) and three surround Lake Winnebago (137,708 acres).[5] The Lake Poygan and Lake Winneconne watershed contains parts of Waushara and Winnebago Counties. The two Lake Butte des Morts watersheds contain parts of Winnebago, Fond du Lac and Green Lake Counties. The Lake Winnebago watershed contains parts of Winnebago, Fond du Lac and Calumet Counties. In addition to the 3,278 square mile drainage area of the Wolf River at Lake Poygan, the Rat River, Pine River, and Lake Poygan and Lake Winneconne watershed add an additional 453 square miles of drainage area. The additional drainage area of the upper Fox River and the tributaries to Lake Butte des Morts increases the total drainage area of the project stream at Oshkosh to about 5,610 square miles.[6] The addition of the Lake Winnebago watersheds increase the drainage area at the Neenah and Menasha dam entrances to the Lower Fox River to 6,030 square miles.[7]

2.06
Lake Winnebago is the largest inland lake in Wisconsin. It has a maximum length of 28 miles, a maximum width of 10.5 miles, a maximum depth of approximately 21 feet, and an average depth of 15.5 feet. The lake is located in a flat clay region except along the east and northeast shores where the area is bounded by the Niagara limestone escarpment which extends southwesterly from Door County along the easterly shore of Green Bay, the easterly boundary of the Fox River basin, and the east shore of Lake Winnebago. Most of the area surrounding the lake is devoted to agriculture, except for urban developments in the Fond du Lac, Oshkosh, and Neenah-Menasha areas. Most of the immediate lake shore, except where too low for housing development, is occupied by summer cottages and permanent homes.



*Zero of Gage - Elevation 747.94 (M.S.L. Adj. 1929)

Fig. 2.4. Floods of the Wolf River, Wisconsin. Location of gage, Pearl Street Bridge, New London.

2.07
Lake Winnebago, with its tributary lakes and marsh areas, is the natural retarding basin to reduce flood peaks on the Lower Fox River. It serves as a storage reservoir for the drainage from the Upper Fox River, the Wolf River, and about 600 square miles of local drainage around the lake. Lake Winnebago, together with the six smaller lakes within the lower portions of the Upper Fox and the Wolf Rivers basins, forms what is known as the Lake Winnebago pool with a total low-water area of 265 square miles at ordinary low water elevation. At maximum high water of record with prevailing backwater slopes in the connecting channels, the pool area is increased to about 320 square miles. During maximum floods about 80 percent of the stream discharge overflows the banks and fills the extensive marshy areas along the river to widths of 2 to 5 miles.

2.08
The central region of the project area, like the Wolf River region noted previously, is also subject to flooding. Table 2.1 shows flood data on this section of the project area. The intermediate regional flood (100-year flood) elevation at the outlet of the Upper Fox River into Lake Winnebago is about 749 feet (MSL).

Table 2.1. Flood Crest Stages and Elevations for Historical Floods on Lake Winnebago

Year	Date of Crest	Stage (Oshkosh gage)	Elevation (MSL-1929)
1881	8 November	5.61[a]	749.51[c]
1886	1 May	4.33[a]	748.23[c]
1888	21 April	4.42[a]	748.32[c]
1922	23 April	4.75[b]	748.81[c]
1929	16 April	4.17[b]	748.23[c]
1960	17 May	4.32[b]	748.38
1969	29 June	3.86[b]	747.92
1973	25 March	3.89[b]	747.95

[a] *Zero gage datum is equal to 743.90 MSL-1929.*

[b] *Zero gage datum is equal to 744.06 MSL-1929.*
NOTE: Oshkosh gage datum raised 0.16 feet on March 23, 1898.

[c] *Flood levels prior to 1937 would have been lower under current conditions because of the increased sluicing capacities of the Menasha and Neenah Dams.*

2.09
The project region containing the Lower Fox River consists of a bed rock-bottomed river cut between mildly to sharply rising clay bluffs. The river bottom has several small shoreline floodplains and a few islands in the stream bed itself. Along the route from the Neenah and Menasha dams to the De Pere locks, the width of the river varies from about 500 to 1,000 feet. Most of the land along the immediate river banks is highly developed industrial area occupied by several cities, paper mills, power plants, and other improvements. The remainder of the drainage area below Lake Winnebago is well developed agricultural land. The Lower Fox River passes through the cities of Neenah and Menasha; into Little Lake Butte des Morts; through the city of Appleton; adjacent to the communities of Kimberly, Combined Locks, and Little Chute; through the city of Kaukauna; and through the city of De Pere.

2.10
The Lower Fox River is 39 miles long from Lake Winnebago to its mouth. The portion of the river within the project area falls about 166 feet from Lake Winnebago to just below DePere dam which is 7 miles above the mouth, for an average slope of 5.2 feet per mile. To provide for navigation, locks and dams with canals along the rapids sections were constructed, thereby converting the free-flowing channel into a series of slack water pools.

2.11
The drainage area of the lower river below Lake Winnebago is only 400 square miles. The principal tributaries are the East River, Dutchmans Creek, and Ashwaubenan Creek, all entering below De Pere, and Apple, Plum, Mud, and Neenah Creeks, entering between 16 and 35 miles above the mouth of the river. The total for the entire Fox River system above the river mouth is 6,430 square miles.

2.12
The climate in the Wolf-Fox project study area is typically continental with cold winters and hot summers. The recorded maximum temperature range at Green Bay has been from -31°F to +99°F.[8] The climate is more severe at the higher elevation and land locked parts of [illegible] valley since the climate at Green Bay (city) is modified by the [illegible] Green Bay and Lake Michigan. New London has a mean value of 14[illegible] frost-free days compared with 161 for Green Bay and 151 for Fond du Lac.[9] The average temperature of New London is 45.7° compared with 43.6° for Green Bay and 47.0° at Fond du Lac reflecting a more constant although colder climate at Green Bay.[9] Precipitation averages 30.6 inches at New London, 29.2 at Fond du Lac and 26.5 at Green Bay. Approximately 60 percent of the annual precipitation falls during the months of May through September. June is generally the rainiest month of the year. Severe drought is quite rare.[9]

2.13
Most of the Wisconsin landscape is snow covered and the streams are ice covered from late November to early March. In spring, rains and melting snow usually cause some flooding in the area. During the spring ice breakup, damage to shorelands and property along the shorelines can occur in the lakes of the Winnebago pool due to wind-driven ice flows.

2.14
Prevailing winds in the Fox-Wolf Basin are from the west and northwest from late fall through mid-spring and southerly the remainder of the year. April and November are the windiest months with averages of about 12 miles per hour. Wind speeds have been under 15 miles per hour three-fourths of the time, between 15 and 30 miles per hour one-fourth of the time, and greater than 30 miles per hour less than one percent of the time. The strongest winds usually blow from a westerly direction.

2.15
Annual lake evaporation is estimated at approximately 28 inches in the southern portion of the basin and about 25 inches in the north. About 80 percent of the year's total evaporation occurs in the warm season period of May through October.

Surface Water Features

2.16
The majority of surface water features in the project study area are part of, or tributary to, the Wolf-Fox River drainage system which empties into Green Bay. Table 2.2 indicates the area of the water surface expected to directly affected by the proposed project activities. The surface water features in each portion are detailed below.

Table 2.2. Approximate Surface Area of Streams and Lakes in the Project Area

Lakes	
Partridge Crop	263 acres
Partridge	990
Cincoe	115
Poygan	10,992
Winneconne	3,264
Butte des Morts	9,235
Winnebago	137,708
Little Lake Butte des Morts	1,150
Streams	
Lower Wolf (47 miles) (New London - Lake Butte des Morts)	1,424
Lower Fox (33 miles) (Appleton to De Pere Dam)	3,000
Total	168,131 acres

2.17
Wolf River Region - The region consists of the lower Wolf River from New London to its mouth at Lake Poygan, and several off-channel lakes: including Partridge Lake, Partridge Crop Lake, Cincoe Lake, and the Waupaca River confluence.

2.18
Central or Lake Region - The middle portion consists of the Winnebago pool at standard low water (elevation 746.01 MSL). It should be noted here that at high water stages the lower Wolf and associated off-channel lakes become part of the Winnebago pool. At ordinary low water elevations the area of the Winnebago pool is 265 square miles (169,600 acres), at ordinary high water (21-1/4 inches above crest at Menasha dam) the pool area increases to 320 square miles (204,800 acres).[10]

2.19
Fox River Region - This region consists of the Lower Fox River and includes the Little Lake Butte des Morts and several small tributaries to the Fox: including Apple Creek, Mud Creek, Plum Creek, and Kankapot Creek.

Surface Water Quality

2.20
The water quality standards for the State of Wisconsin are based on three use categories and are summarized in Table 2.3. In addition, unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic to fish or other aquatic life.

2.21
With the exception of the segment of the Lower Fox River below Wrightstown, project area waters are designated to meet the standards for fish and aquatic life and recreational use. Lake Winnebago and the Fox River from Lake Winnebago downstream to the upper dam in the City of Appleton are designated to meet public water supply use standards. Those waters which, because of natural conditions or pollutional inputs not reasonably removed, cannot meet these high quality standards are allowed specific variances from that standard. In all cases the variance is for an alteration from the dissolved oxygen and/or the fecal coliform criteria only. The variance does not preclude a waste source from providing a high level of treatment for the wastewater nor does it allow existing polluted conditions to continue.

2.22
The water-quality data presented in this document are derived from different published documents and uniformity of reported data was not possible. In addition, the data presented can only be used to form general judgments since water-quality conditions are changing rapidly in the basin due to increased pollution control, urbanization, and the diverse development trends in riparian areas. A discussion of water quality in the Wolf-Fox project area is also best divided into separate discussions of the three physiographic regions. The nature, problems and levels of information are quite different for each region.

Table 2.3. Wisconsin Water Quality Standards

Water Quality Parameter	Standard
	Water Used for Fish and Aquatic Life
Dissolved Oxygen (D.O.)	Not less than 5 mg/l at any time. In trout streams, the D.O. shall be not less than 6.0 mg/l.
Temperature	Maximum temperature rise shall not exceed 5°F for streams and 3°F for lakes. The temperature shall not exceed 89°F for warm water fish.
pH	6.0 to 9.0 with change no greater than 0.5 units.
	Water Used for Recreation
Fecal coliform	Not to exceed 200 ml per 100 ml or not less than 5 samples per month nor to exceed 400 per 100 ml in more than 10 percent of the samples during any month.
	Public Water Supply*
Dissolved solids	Not to exceed 500 mg/l as a monthly average value, nor exceed 750 mg/l at any time.

**This water should also meet the standards for fish and aquatic life and recreational use.*

Source: Wisconsin Administrative Code, Chapters NR 102, NR 103, and NR 104. 1973. Wisconsin Water Quality Standards. Effective Oct. 1, 1973; Amended August 1, 1975.

2.23
Wolf River Region - The surface waters of the Wolf River basin generally do not experience significant pollution problems. Due to the low population density and the rural nature of the area, domestic and industrial waste discharges are relatively small compared to the flow in basin streams.[11] There are, however, localized areas where discharges affect the quality of surface waters. The primary source of pollution in the Wolf River basin is that generated from sewage wastes.[11] Industrial waste is noted from small industries throughout the basin. The food processing industry is the largest generator of industrial wastes in the basin. Land disposal techniques are the methods most often employed for treating these wastes. Agricultural runoff is also a contributor to the siltation and eutrophication of surface waters in the basin.

2.24
The Wolf River in its upper reaches well above the project limit at New London, is largely a natural stream with few substantial sources of urban or industrial pollution on either the main stream or tributaries.[11] In general, pollutants are assimilated in a few miles or less with no permanent damage to the water quality of the streams other than the addition of small increments of nutrient enrichment, e.g., nitrogen and phosphorus compounds.[11] Also, the gradient (stream elevation change) is high, thus, promoting a high degree of aeration and oxidation of organic materials.[11]

2.25
In the lower hundred miles of the Wolf River, conditions are substantially different. The gradient is very low (56 feet in 114 miles), and farm runoff and siltation become significant.[11] At New London and downstream, towns in the Wolf River drainage area begin to contribute substantial amounts of organics, which increase biological oxygen demand, as well as inorganic nutrients.[11] In addition, sewage treatment plants in the cities of Waupaca and Weyauwega on the Waupaca River contribute sizable quantities of wastes. Smaller communities and homes with individual septic tank-tile field sewage systems also contribute substantially since soil permeability is low and much of the runoff goes directly into the streams.

2.26
Tabular information on the Wolf River water quality is given in Appendix B, Table B.11. Although fluctuations within water quality parameters are normally very large on the Wolf River, it can still be seen that pollution levels do increase on passing downstream through the cities. A large increase in turbidity was noted at Winneconne probably from the high turbidity of Lake Poygan.

2.27
Although the dissolved oxygen level drops as low as 4.2 ppm at Fremont, a level that is restrictive to some fish species, in general it can be considered adequate for the resident biologic populations. At times, photosynthezing algae in the lower part of the river cause supersaturation of oxygen. Average nitrate levels at Keshena are borderline with

respect to triggering extensive algal growths; however, below New London, both the levels of nitrogen and phosphorus are sufficient to feed extensive algal blooms.

2.28
The bottom of the Wolf River throughout the project area is mostly sand with some areas of red clay. In general, bottom pollution from human sources seemed to be localized near the sewage outfalls.[11]

2.29
It is unlikely that the Wolf River basin as a whole will experience great increases in industrial and manufacturing activities of a type which will cause heavy pollutional loadings in the foreseeable future.[11]

2.30
Central or Lake Region - Appendix B, Table B.12, shows that Lake Winnebago is a very eutrophic lake. The drainage basin of Lake Winnebago is largely comprised of agricultural areas. The fertilizer run-off from these areas is rich in nutrient nitrogen and phosphorus providing ideal conditions for the growth of algae in the Lake.[13] As a result, high nutrient levels are present in the lake and heavy algal blooms do occur. Dissolved oxygen is generally sufficient to support biological activity at all times, although the oxygen levels do decrease under the ice in winter and in the warmer shallow areas in summer. The extensive algal growths create a serious esthetic and water treatment (for municipal supplies) problems in summer.

2.31
Over the past years, BOD measurements taken on the Lower Fox near Lake Winnebago, have shown that considerable natural pollution may exist in the river above the Neenah-Menasha dams. The term "natural pollution" is used because investigations have shown that there are no significant sources of either human or industrial pollution in the area of influence above Neenah-Menasha. The cities of Oshkosh and Fond du Lac discharge secondary treated sewage.

2.32
The bottom of Lake Winnebago is mostly silt and red clay. In the lake region of the study area, particularly in the marshy areas of Lakes Poygan and Butte des Morts, areas of highly organic natural detritus (gyttja) containing high nutrient levels, comprise much of the substrate.

2.33
Survey data (Appendix B, Table B.13) indicate that Lakes Poygan, Winneconne, and Butte des Morts are also eutrophic. Lake Butte des Morts is shallow and very eutrophic and historically has always been eutrophic, although since 1966 it has changed from a clear-water lake dominated by macrophytes and bog-like areas to a rather turbid water body from which aquatic plants and bog areas are disappearing.[69]

2.34
Lower Fox River Region - The Fox River in the 40 mile-reach between the Winnebago pool and Green Bay has on its banks one of the major industrial complexes in the Midwest. This concentration of industry and municipalities imposes a pollutional load on the river which requires control. There are only a few small tributaries below Lake Winnebago. The major changes in the water quality in this section of the Fox River are created by the 18 paper and pulp mills and 11 municipal sewage systems emptying wastes into the river.[14]

2.35
In 1971 an automatic monitoring system was established by the State of Wisconsin to provide a continuous water quality record for the Lower Fox River. The Lower Fox River receives large amounts of organic wastes from the pulp and paper industry resulting in marked changes in water quality. Each day the Lower Fox River between Lake Winnebago and Green Bay, where the flow averages 4,139 cfs, receives an estimated BOD loading of 26,000 pounds from municipal sources and 191,000 pounds from pulp and paper mills as shown in Table B.14, Appendix B. Continuous monitoring of the streams is necessary to document improvements in water quality which are expected to occur as pollution abatement programs are implemented and to identify locations where further abatement action will be required. The system consists of five stations that monitor dissolved oxygen, temperature, pH, conductivity, and turbidity. The monitors are unattended and measure the values of each of the parameters by means of probes placed in the water flow.

2.36
Dissolved oxygen levels in segments of the monitored sections of the Fox River are subject to marked fluctuation and are insufficient to support many forms of aquatic life during the low flow, warm water conditions of summer and during the winter period of ice cover. The Department of Natural Resources has worked with the municipalities and the pulp and paper mills to reduce discharges of BOD and other wastes to the rivers. Wastewater treatment facilities have been improved and are being expanded. Before this task is finished many millions of dollars will be spent in construction and maintenance costs for pollution abatement. Continuous monitoring of the Lower Fox River is an essential part of the water pollution abatement program.

2.37
The effects of flows on the dissolved oxygen can be seen in several examples given in Figures 2.5 and 2.6. Other factors also affect dissolved oxygen fluctuations on a daily basis. These factors include concentrations of algae in the summer, aeration by the wind, the turning on and shutting off of auxiliary turbines at hydroelectric power facility dams housing the monitors and other factors.

2.38
The lower dissolved oxygen values occur during the warmest months of summer in those stretches of the rivers most affected by the oxygen demand of the organic wastes discharged to the river. The lowest daily

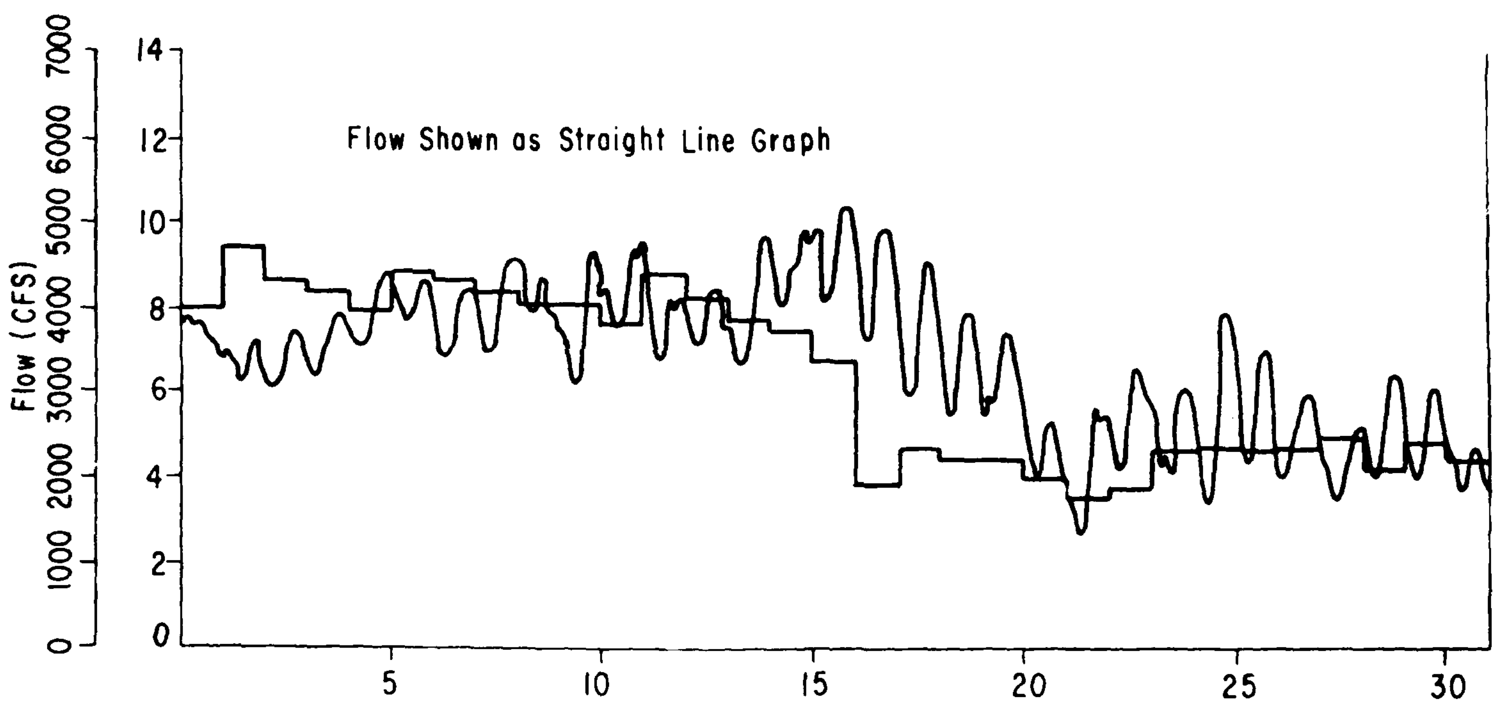


Fig. 2.5. Flow and D.O. Interdependency on the Fox River Above Appleton - July, 1973

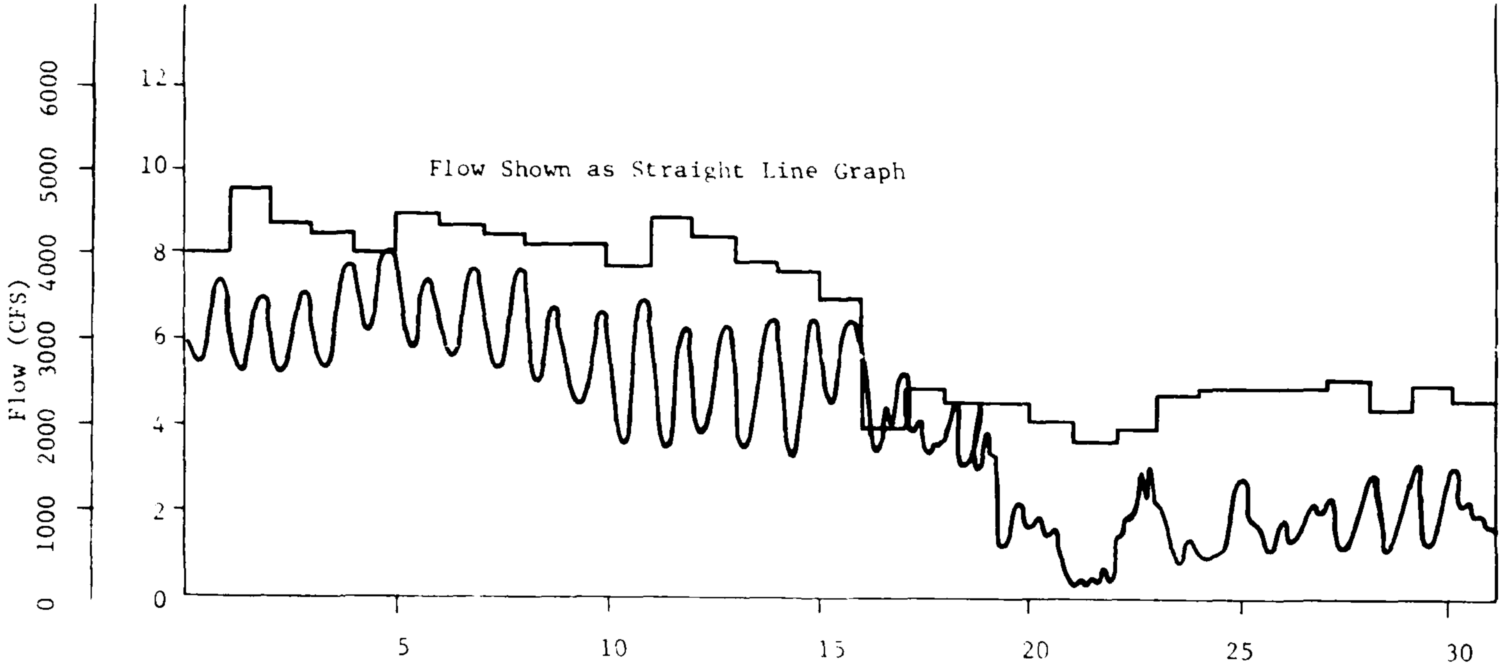


Fig. 2.6. Flow and D.O. Interdependency on the Fox River at Rapid Croche - July, 1973

average dissolved oxygen values occur at Rapid Croche and Green Bay. In winter the oxygen demand of the organic wastes can be most pronounced below the monitoring systems in Green Bay several miles from the mouth of the Fox River.

2.39
The temperature of the Lower Fox ranges from a low of 32°F to a high of 80°F. Closely associated with the temperature is the dissolved oxygen. The oxygen demand of the water and temperature are the primary factors governing the waters' ability to hold dissolved oxygen. Yearly dissolved oxygen concentrations range from a low near zero mg/l in some locations in the late summer to a high of about 15 mg/l in the early spring and late fall. Low dissolved oxygen concentrations also occur in winter during freeze-over due to the lack of natural aeration which takes place as a result of variations in river flow rates, wave action, and spillways over dams.

2.40
The average pH of the Lower Fox River falls in the range of 7.0-9.0.

2.41
The conductivity of the Lower Fox River gives a general feeling for the amount of dissolved solids present in each of the streams. The conductivity range in micromhos of the Fox River is 250-400. Conductivity varies with the season and the location along the stream. The highest concentrations occur during the low flow periods of fall and winter. Conductivities are also higher in the downstream monitoring stations of the river.

2.42
The initial water quality of the Lower Fox River is largely determined by Lake Winnebago water quality which has a relatively high nutrient content, high organic content, and a moderate dissolved oxygen level. Table B.15, Appendix B, gives the average concentrations for a number of river water quality parameters at the Lake Winnebago outlet.

2.43
Lake Winnebago waters contain abundant algae populations and algal blooms which are carried into the Lower Fox and can be found throughout the river and Green Bay. BOD measurements during the various months exhibit a constant degree of variation as shown by relatively constant standard deviations. BOD values generally follow the algal cycle, increasing from a minimum in June to an August maximum. This indicates that some of the measured BOD may be due to algal respiration. Comparison of autoclaved and normal BOD's performed during various stream surveys indicates that the algae may also contribute an actual BOD, as well as a respiration oxygen demand. The decay of dead algae apparently, however, does not create a serious oxygen demand either in the lake or downstream in the Lower Fox River.

2.44
Seasonal variations in discharge of nutrients and organic matter from the Fox River to Green Bay are related to the quality of Lake Winnebago discharges and to processes of assimilation, sedimentation and release in

the river. Lake Winnebago's effects on the river include increased levels of ammonia-nitrogen in spring, total phosphate in summer and orthophosphate in fall. Table B.16, Appendix B, shows the seasonal average for a number of parameters in terms of the total flow of the substance in pounds per day.[16] Since many of the parameters are involved in the chemical and biological processes of the river, the differences in value between the upper and lower sites noted do not necessarily reflect the amount of the substance added along the river. The spring (March-May) loadings of nutrients to Green Bay are highest of all seasons and for most parameters represent amounts greatly in excess of that which can be attributed to Lake Winnebago and municipal treatment plants. Surface runoff from the drainage basin and release from the river system are likely sources of the increased loadings observed in the spring.[16] As a source of nutrients for lower Green Bay, Lake Winnebago contributes amounts of nitrogen and phosphorus compounds to the Lower Fox River in excess of or approximately equal to that contributed by municipal treatment plants. Annual average loadings of orthophosphate and total phosphate from municipal treatment plants were 4400 and 6670 lb/day, respectively. Discharges from Lake Winnebago included annual average loadings of ?070 and 6620 lb/day of orthophosphate and total phosphate, respectively. Annual average loading of ammonia-nitrogen from treatment plants was 4440 lb/day and from Lake Winnebago 5200 lb/day.[16] Anoxic conditions in portions of the river indicate excessive organic loading and are significant in ammonia-nitrogen releases. Phosphate assimilation in the river is evident from decreases in loadings between Lake Winnebago and Green Bay in summer and fall. Maximum loadings of phosphates and organics during winter and spring reflect high flows, reduced assimilation and releases from the drainage system.[16]

2.45
The Lower Fox River, because of its size and the degree of contamination, has been one of the greatest contributors to Lake Michigan's pollution problems.[16,17] Partly for this reason, the river has been extensively studied with respect to the pollution sources and water quality, although most studies are restricted to analysis of the oxygen balance and are based on water quality models. Models of river water quality have been developed in order to understand the nature of the pollution[19,20] and to provide a means of improving water quality at a minimum economic cost. Designs for equipment and processes for the improvement of industrial and urban waste cleanup efficiencies will be determined by Wisconsin DNR from the model calculations. The models predict dissolved oxygen levels as a function of time and river location using a number of inputs (e.g., meteorological data, flow rates, and waste inputs). The models consider carbonaceous and nitrogenous BOD, photosynthesis and respiration, and sludge oxygen uptake to be the important sources and sinks of dissolved oxygen. Verification runs show very good agreement with observed data from three surveys conducted by the Wisconsin Department of Natural Resources. Prediction runs made with projected river loadings were developed and used to evaluate the effect of the final limits for the present discharge permits at all point source discharges on the water quality of the Lower Fox River and Green Bay, specifically dissolved oxygen. The most critical dis-

dissolved oxygen case was determined by the model to be the summer low flow, high temperature, nighttime conditions in the river.

2.46
Inadequate treatment of waste water by industries and municipalities over prolonged periods of time has seriously degraded the water quality of the Lower Fox River, to the extent that river water-contact sports and fishing activities are severely limited over a large portion of the river (see Table B.17, Appendix B, for current overall physical and chemical data for the Lower Fox River at Wrightstown). To improve the situation the State of Wisconsin Department of Natural Resources has issued regulatory orders to the industries and municipalities on the Lower Fox River for the construction of adequate treatment facilities, in keeping with the state water quality standards and the recommendations of the Lake Michigan Enforcement Conference.

2.47
Urban and industrial wastes create a very high oxygen demand so that in the middle and lower reaches of the Lower Fox River, frequent periods of very low dissolved oxygen levels are experienced in the summer.[15,16] However, in seasons of high river flow such as spring, there is usually enough water for dilution and a moderate oxygen level is provided throughout the length of the river. On the basis of the model calculations, the State of Wisconsin authorities propose to regulate waste inputs so that the minimum dissolved oxygen level from Appleton to Wrightstown will be 3 mg/l for not more than eight hours per day and 5 mg/l for the remainder of the day. From Wrightstown to De Pere a minimum of 2 mg/l for eight hours will be tolerated. Prior to 1973, a 2.0 mg/l standard applied from the upper dam at Appleton to the confluence with Lake Michigan at Green Bay.

2.48
In order to meet these standards, a number of industries and municipalities are presently upgrading their treatment systems. A listing of the major pollution sources to be expected in 1977 is given in Table B.18, Appendix B. Nevertheless, with all dischargers limited to "Best Practical Treatment" (BPT) serious oxygen problems will still be present in the Lower Fox River. BPT is used in this report to refer to the discharge levels to be attained by the end of 1977. In some cases the permits are slightly lower than BPT but in general they represent Best Practical Treatment. Dissolved oxygen modelling of the Lower Fox River indicates that an average reduction of the 37% below BPT will be required to maintain 5.0 mg/l of dissolved oxygen at all points along the river during the low flow and high temperature period. The waste load allocation developed by the model takes into account the suspended solids reductions at each discharge location. A critical assessment of the actual total feasibility of requiring still higher levels of treatment beyond the present level of practical effluent treatment technology has yet to be completed.

2.49
River deoxygenation occurs when oxygen is a reactant in a physical, chemical or biochemical reaction. In the Lower Fox, physical deoxygenation can occur by gas stripping in hydro-station forebays during periods of intense sludge gasification. Chemical deoxygenation can occur by reaction with spent sulfite liquor waste to the River. Major amounts of untreated sulfite liquor are no longer discharged directly to the River. Biochemical deoxygenation is caused by assimilation of suspended and dissolved BOD and by bottom deposit metabolism.

2.50
The three primary factors contributing to low oxygen levels on the Lower Fox River are first the BOD levels of the effluent discharges to the river, which directly affect the oxygen levels, and second the oxygen demand of the bottom sediments or 'sludge', which is potentially affected by the reduction in suspended solids discharges. A third factor is the flow rate of water which is allowed through the dam at Neenah into the Lower Fox River.

2.51
All major sources of BOD loading contributed to the river have been identified and the state has issued orders applying to each individual effluent source, the major source being the paper and pulp mills in the valley. Actually, oxygen demand is contributed preferentially from pulping operations, and solids turbidity from paper making. Fiber may be contributed by either process. Although the mills do treat their wastes and/or discharge them through municipal systems, much of the waste material still does reach the river. In Table B.19, Appendix B, the waste loadings from 17 pulp and paper mills discharging into the Lower Fox River are summarized for a ninety-day period in 1972.[103] Two other mills, the Wisconsin Tissue Mills and the U.S. Paper Mills, are also listed to show their contribution to paper and pulp production, even though they have no direct discharge into the river. In general, only primary clarification was available at the time the data were assembled. This situation is changing as individual mills either improve treatment capabilities or direct their wastes into combined municipal-industrial facilities.

2.52
Deposition of paper mill and sewage solids, discharged to the Lower Fox over a period of many years, has also resulted in the formation of oxygen demanding biological deposits. The oxygen demand from sediments on the Lower Fox River is a very significant factor in its overall oxygen budget. The actual demand exerted by the biodegradation process occurs only in the uppermost layer of the accumulated sludge. Consequently, the oxygen-demand of a relatively shallow sludge deposit is potentially as great as the demand of a deposit several feet deep.

2.53
In 1970 the fibrous organic sludges from paper mill sources were estimated to cover about half the river bottom area to depths of from

6 inches to several feet.[23] Locations of these beds are shown in Figure 2.7. The locations of these beds are not permanent but change due to river currents removing and redepositing the beds and biological decomposition. It has been estimated[23] that about 5/6 of the riverbed is subject to shifting sludge beds while about 1/6 of the riverbed is either totally free of such sludge beds or contains permanent sludge beds.

2.54
If the 1972 Wisconsin Department of Natural Resources standards are met for paper mill effluents, the yearly addition of sludge is expected to be balanced by the yearly decomposition.[23] If no additional sludge buildup occurs, the time of total decomposition of the existing sludge is estimated to be one to two years. Table B.20, Appendix B, gives analyses of the river's water associated with sludge beds, and Table B.21, Appendix B, gives the results of trace metal analyses for three specific beds. Except for mercury, which was not reported, and zinc the concentrations of metals should not be deleterious. Solids content of other sludge beds ranged from 22 to 44%, Kjeldahl nitrogen ranged from 0.45 to 0.94%, and free ammonia ranged from 0.008 to 0.06%.[23] Prediction of future sludge bed chemical constituents at this point in time is not possible since significant improvements to the effluent control systems of the dischargers are presently in process. The data cited above is historic and, therefore, does not reflect these ongoing improvements.

2.55
Analysis for toxic metals were made in the sewage effluents of Neenah-Menasha and Kaukauna.[21] No significant toxic metal discharges were found. In another study conducted in 1971 of both water and sediments, mercury concentrations in the water was found to be 0.0008 ppm at Appleton and 0.0045 ppm at Mason Street in the City of Green Bay.[22] Neither of these levels in water is considered to be toxic. Sediment contents ranged from 0.34 ppm at Appleton to 3.3 ppm in Kaukauna, and 3.6 ppm above the De Pere dam.[22] High mercury levels are probably due to the use of mercury-containing slimicides in the paper mills; however, the State of Wisconsin ordered this practice stopped in 1970. For comparative purposes, it should be noted that Lake Michigan mercury levels are less than 0.0002 ppm.[22]

2.56
River flow is the final primary factor affecting dissolved oxygen levels on the Lower Fox River. The actual volumetric flow rate of water is important because it determines the initial bulk input of oxygen to the Lower Fox River. In longer streams the initial flow input is not very significant, since over many stream miles the accumulated reaeration capacity of the stream overshadows the initial input. For a short river like the Lower Fox, and especially because of the decreased reaeration capacity of the impoundments, the initial oxygen input is peculiarly significant.

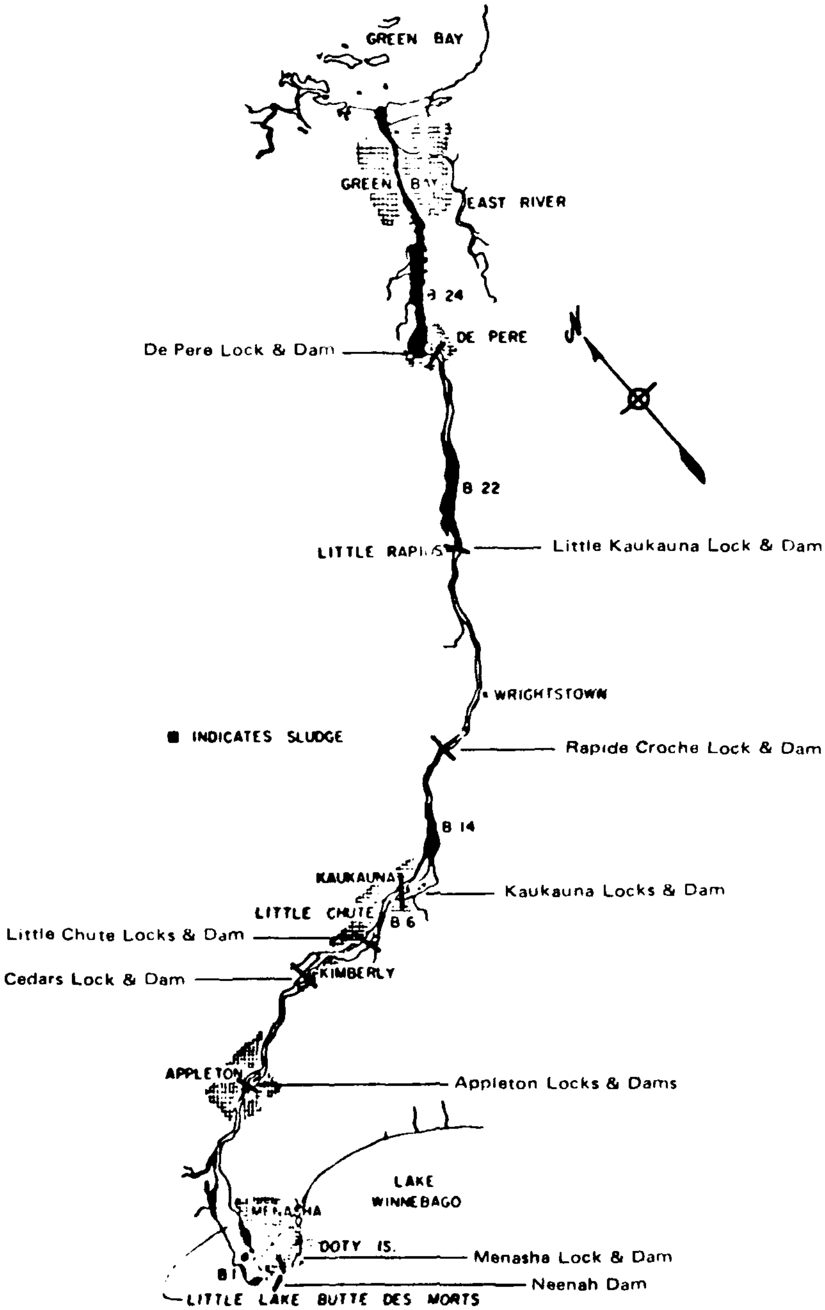


Fig. 2.7. Distribution of Sludge Beds in the Lower Fox River. From A. M. Springer, "Investigation of the Environmental Factors which Affect the Anaerobic Decomposition of Fibrous Sludge Beds on Stream Bottoms," University Microfilms, 1972.

2.57
Under the present operating rules, the flow in the Lower Fox River is a minor consideration. According to existing law, the primary consideration is to maintain high lake levels for navigation purposes. Although attempts are made to reconcile conflicting pressures to maintain high lake levels for recreation while releasing as much water as possible for power generation and waste assimilation in the Lower Fox River, under the system of regulation adopted the level on Lake Winnebago is seldom allowed to fluctuate more than a fraction of the legally allowable range. Under these operating rules, the flow in the Lower Fox fluctuates widely and can be swiftly reduced to quite low values during dry periods to maintain the level in Winnebago, and this further reduces the amount of dissolved oxygen being supplied to the Lower Fox. Records from a U. S. Geological Survey stream flow gauging station at Rapids Croche Dam show the variability of the flow. The monthly mean flow ranges from a maximum of 7,000 cfs in April to a minimum of 2,300 cfs in September. A more complete range of the monthly mean flows can be seen in Figure 2.8, which includes reservoir releases data from 1896-1970. The maximum recorded flow of 24,000 cfs was observed on April 18, 1952, and the absolute minimum of 138 cfs was recorded on August 2, 1936.

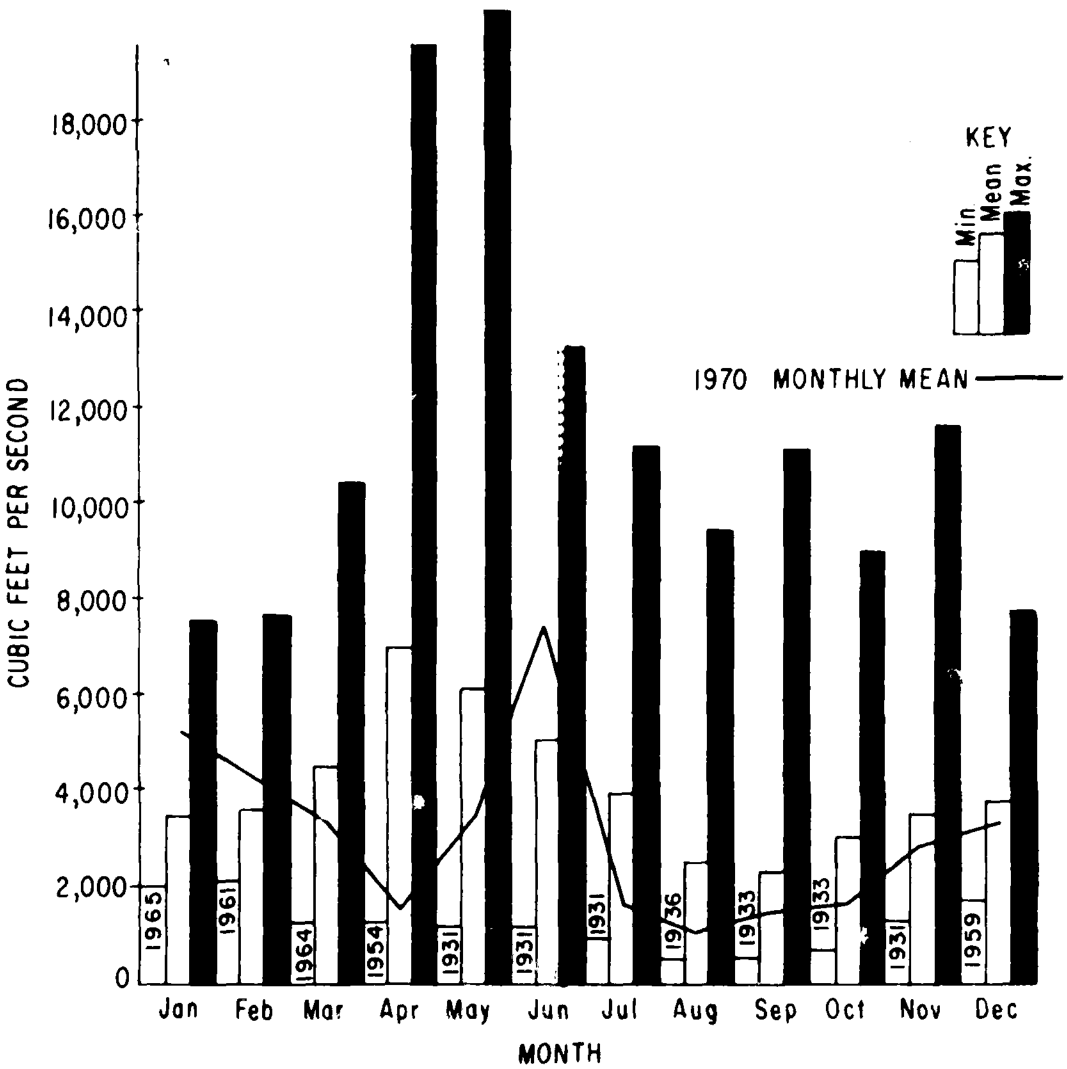
2.58
Attainment of the objectives prescribed by the 1972 Federal Water Quality Act will require a total regional and cooperative effort and it is possible that the current programs of industry and municipalities may have to be supplemented by low flow augmentation at times of low flow. To illustrate the potential value of project storage for low flow augmentation purposes, a depth of one foot on the Winnebago pool at normal levels equals a continuous, uniform flow of 1,000 cubic feet per second for 85 days, or a total volume of 7,355,000 cubic feet.

Suitability for Specific Uses

2.59
Domestic - Municipal - The waters of the Wolf region are generally suitable for domestic use. Hardness, high iron content, high sulfate, and coliform bacteria present management problems. The water of Lake Winnebago and the Lower Fox River require very extensive treatment before they are suitable for domestic use.

2.60
Industrial - The waters of the Wolf and central lakes region are reasonably well-suited for industrial uses. The surface water quality of the Fox River is somewhat comparable to other parts of the industrial midwest. For most industrial uses at the present site of use, treatment including filtration to remove suspended solids and floating objects; aeration to remove iron; softening to reduce hardness; and clorination to prohibit slime formation is required.

2.61
Recreation - There is no general consensus of opinion on the suitability of water for recreation. For example, boating does not necessarily



Source: U. S. Geological Survey (1896-1975)

Fig. 2.8. Monthly Mean Discharge at Lake Winnebago Outlet

demand aerated, clean water; swimming, however, requires good water quality and sport fisheries can tolerate only certain limits of oxygen deficiency.

Groundwater

2.62
Groundwater in the project study area occurs under both water-table (unconfined) and artesian (confined) conditions. The available groundwater under water-table conditions is found in the glacial drift and near surface bedrock aquifers.

2.63
In the study area the glacial drift deposits generally are thin and have low permeability due to high clay content. Yields from these aquifers range from 5 to 100 gpm.[24]

2.64
The bedrock aquifers occur throughout the study area. The sandstones of the Cambrian and Ordovician systems form the principal (and artesian) bedrock aquifer. These units are hydraulically connected, act as one aquifer, and can yield up to 1,000 gpm.[24] In the Plattville-Galena formations water occurs in fractures, joints and bedding planes. Yields are generally less than 50 gpm. The Niagara Dolomite is an important aquifer in the region (yields up to 100 gpm)[24] but it lies to the east of, and outside of the study area.

2.65
Groundwater in the project study area is a renewable resource replenished (recharged) by precipitation. The near surface aquifers that contain water under water-table conditions receive recharge by direct percolation of water from the surface to the zone of saturation. The deeper formations that contain water under artesian conditions receive recharge by water moving down dip from areas of outcrop to deeper parts of the same formation. Normally, recharge to the groundwater reservoirs is greater in spring when the ground thaws and snow melt and rainwater percolates into the soil.

2.66
Groundwater is discharged naturally from an aquifer by seepage into streams and lakes, by evapotranspiration, and by springs. Artificial discharge results from pumping or flowing wells. The project study area streams and lakes are areas of discharge to which groundwater contributes most of the flow approximately 90 percent of the time.[24]

2.67
The movement of groundwater is controlled by discharge, recharge, topography, and the structure and permeability of the rocks. The movement is locally altered by pumping and recharge or discharge from man-made reservoirs. Groundwater moves through an aquifer from areas of recharge

to areas of discharge. The direction of movement in an aquifer is down the hydraulic gradient, from areas of high head to areas of low head. The direction of groundwater movement in the project study area can be determined using the piezometric map (Fig. 2.9). Groundwater movement is perpendicular to the contours on the map. Locally, groundwater moves toward nearby rivers, streams and cones of depression created by heavy industrial and municipal pumpage as at Fond du Lac, Oshkosh and Neenah-Menasha.

2.68
Groundwater levels generally rise in the region in the spring, owing to thawing of the frost zone which permits recharge from melting snow and ice and from rainfall. The levels then gradually decline during the growing season because the natural discharge exceeds the recharge. Soil moisture must be replenished by precipitation before water can recharge the zone of saturation. Small amounts of precipitation cause little, if any, recharge to groundwater. Larger amounts of precipitation may cause a rise in water level or temporarily interrupt the normal seasonal decline. Water levels often rise in the fall after vegetation has been killed by the frost. They then decline until the following spring, because natural discharge continues while recharge is retarded or prevented by the frost zone in the soil.

2.69
Short-term fluctuations reflect intermittent pumping or local day-to-day variations in recharge and natural discharge. The fluctuations occur within minutes or, at most, within a few days and have only a local effect upon water levels and groundwater's storage.

2.70
Seasonal fluctuations reflect variations in recharge and natural discharge. The greatest rise in water levels occurs in the spring owing to snow melt and precipitation. The levels decline during the summer when there is little recharge from precipitation, and when natural discharge by spring flow, evaporation, and transpiration is large. In general, only heavy rains contribute significant recharge with a resultant rise in water level. Water levels continue to decline during the winter, because spring flow continues and recharge is negligible when frost is in the ground

2.71
Fluctuations over a long term reflect differences between recharge and natural discharge from year to year. The largest declines in water level have occurred in the heavily-pumped areas along Lake Winnebago and the Lower Fox River and smaller declines have been recorded in a few other areas of municipal and industrial pumpage.

2.72
Groundwater quality in the project study area varies between [illegible]
drift aquifers and the bedrock aquifers. Generally water [illegible]
glacial drift aquifers has dissolved solids that [illegible]
and some as high as 400 ppm.[4] These high [illegible]
solids are generally in areas where [illegible]

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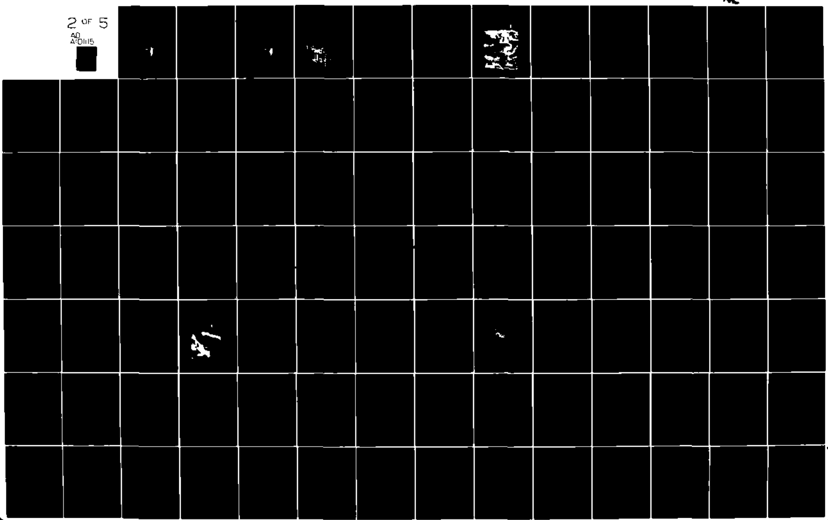

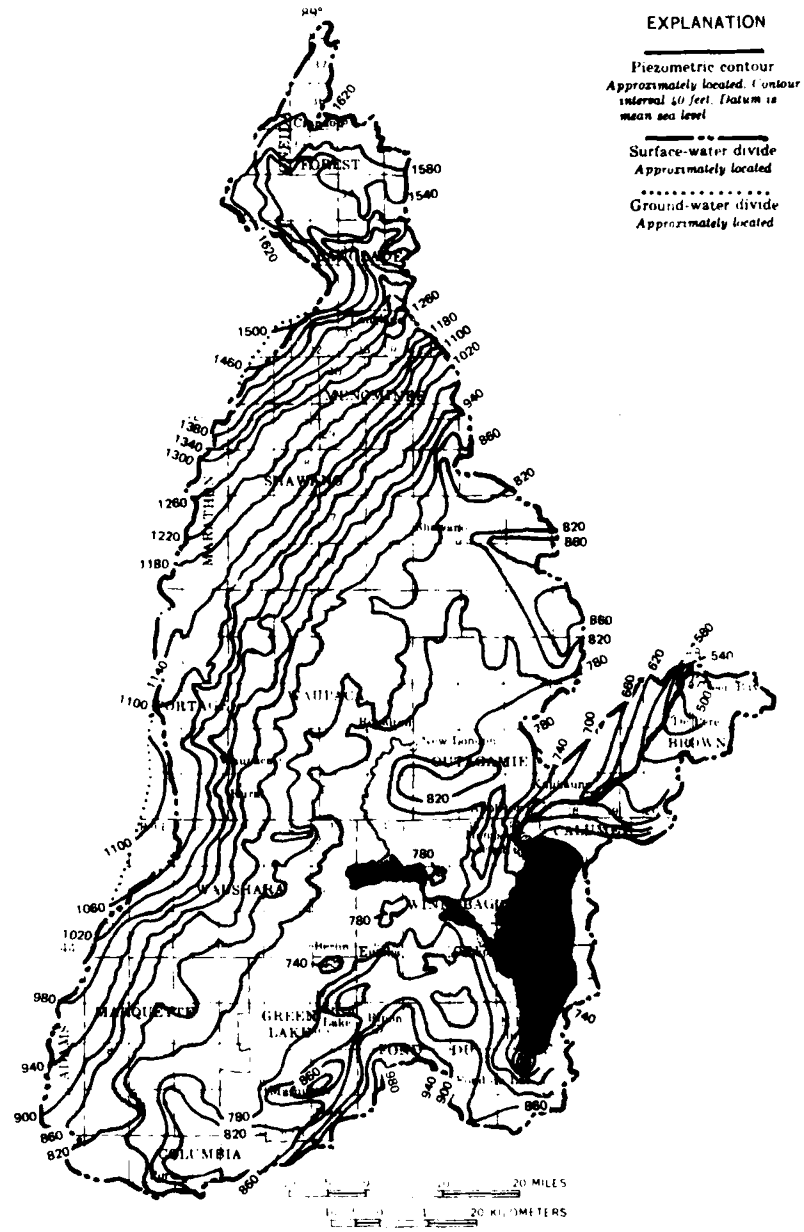

Fig. 2.9. General Piezometric Surface of the Wolf-Fox Drainage Basin. Modified from *P. G. Olcott*, "Hydrologic Atlas," 1968.

moraine predominate. Most glacial-drift water is of the calcium magnesium bicarbonate type, moderately hard, and high in iron, but generally suitable for most domestic uses.

2.73
The mineral content of water in bedrock aquifers generally increases to the southeast. Near Lake Winnebago dissolved solids in the water range from 600 to more than 2,000 ppm, increasing toward the east.[25] The water is of the calcium magnesium bicarbonate type in most of the area, but contains high concentrations of sulfate, chloride, and sodium. The water is hard, and in some places contains high iron concentrations. The quality of water from the bedrock aquifers generally is suitable for most domestic, municipal, and industrial usage.[24]

2.74
Heavy pumpage in the Neenah-Menasha and Oshkosh areas has locally reversed the natural groundwater movement. This may result in moving highly mineralized water from the saline-water zone to the pumping centers and thereby contaminate the sandstone aquifer, at least locally. Indications of this may be apparent through observed increases in sulfate content of groundwater from wells in Neenah.[25] The project study area has generally good quality groundwater available in more than adequate supply for present and projected future development, particularly from the bedrock aquifers.

Geology

2.75
Physiography and Topography - The Wolf-Fox River Basin in east central and northeastern Wisconsin is a sub-basin of the Great Lakes - St. Lawrence Seaway drainage system. The upper portion of the Fox-Wolf River Basin is within the Superior Uplands province. The lower portion of this sub-basin contains the project study area and is located within the Eastern Lakes section of the Central Lowlands physiographic province.[26] Lakes, large and small, are dominant features of this section, including four of the Great Lakes and thousands of lesser ones. This physiographic section is generally blanketed with glacial drift of late Wisconsin substages and displays a freshness of glacial topography typifying the Central Lowlands Province. Prominant end moraines, outwash plains, closed basins (sites of lakes or swamps), eskers, and drumlins are abundant. Till plain topography is rare but areas of gently rolling ground moraine are found between end moraines. The lake basins have varied origins. Some are glacially modified preglacial lowlands, others are the result of irregular deposition of glacial materials (Lake Winnebago), still others are kettles in pitted outwash plains.[26]

2.76
The central and southeastern portion of this basin, the area of controlled discharge (Fig. 2.10), is the area of primary concern relative to this project and its potential impacts. Locally this portion of the Fox-Wolf River Basin extends across two geomorphic subdivisions, the Central Lowlands and the Eastern Ridges and Lowlands (Fig. 2.11).[27] In general,

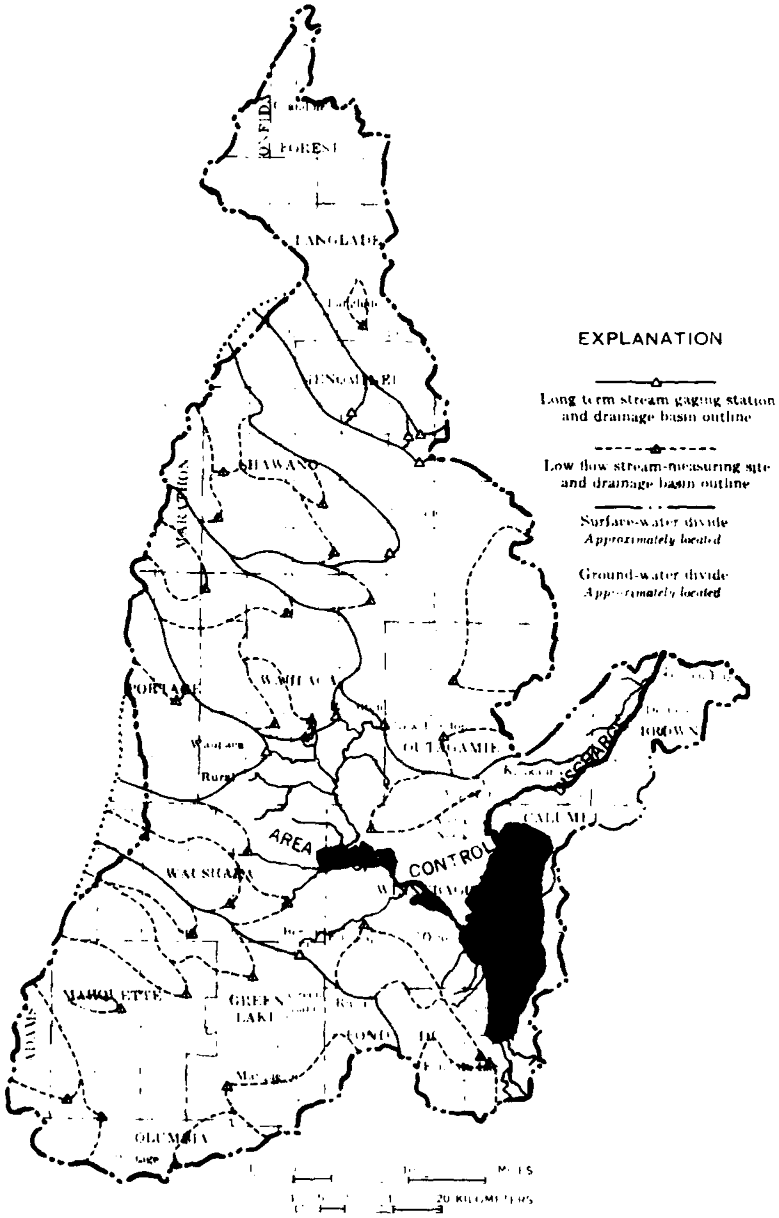

Fig. 2.10. Area of Controlled Discharge in the Wolf-Fox Drainage Basin. Modified from P. G. Olcott, "Hydrologic Atlas," 1968.

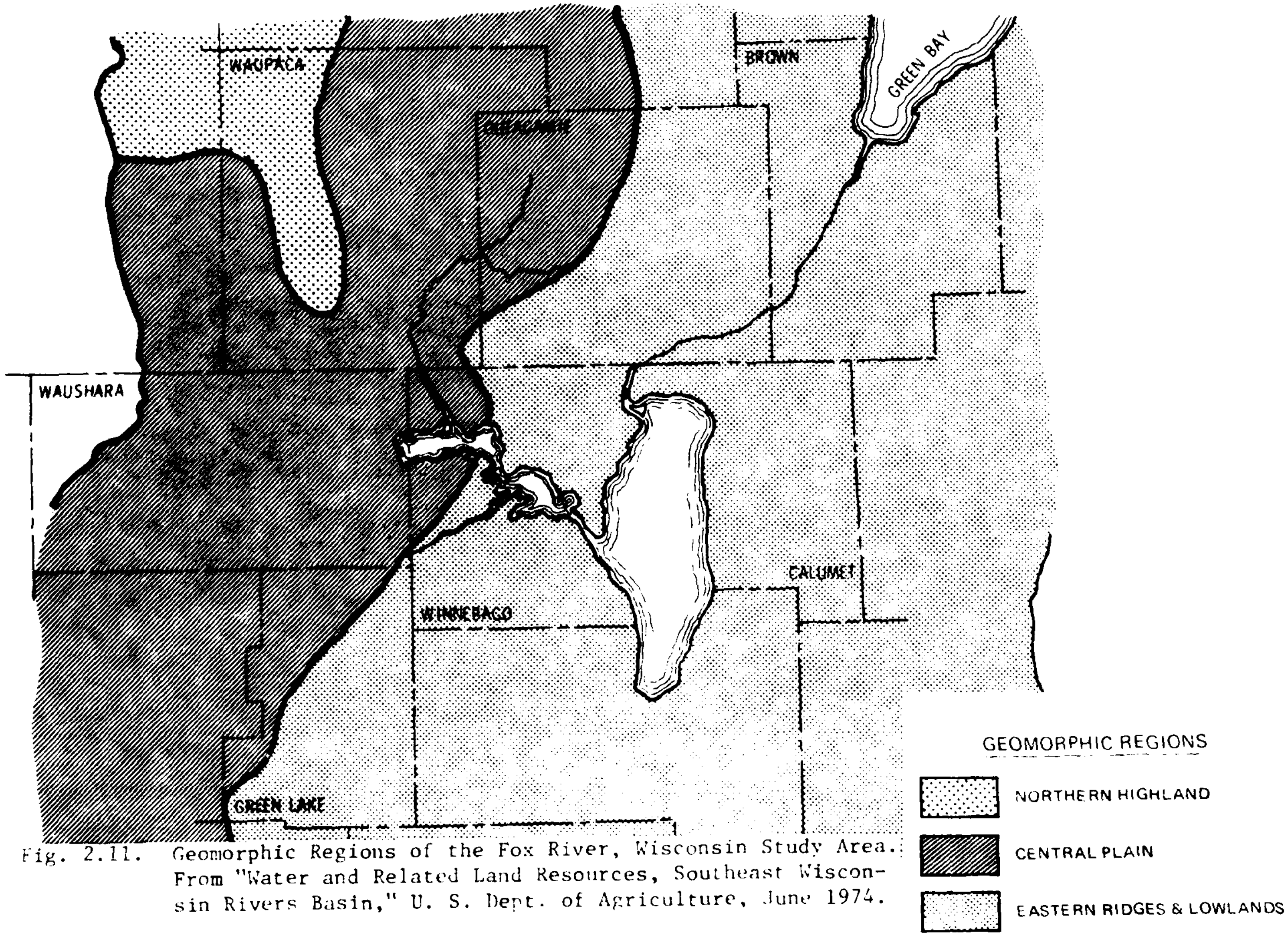

Fig. 2.11. Geomorphic Regions of the Fox River, Wisconsin Study Area. From "Water and Related Land Resources, Southeast Wisconsin Rivers Basin," U. S. Dept. of Agriculture, June 1974.

the topographic features are controlled by the bedrock surface as modified by glaciation.

2.77
The Central Plain is characterized by a generally flat to gently rolling surface. Relief is low except for occasional resistant bedrock pinnacles and hills. Elevations range from 750 to 1000 feet MSL.[28]

2.78
The Eastern Ridges and Lowlands portion of the basin contains numerous natural lakes and varies from gentle slopes of flat lake plains to rolling and hilly ridges with a relief of 100-250 feet. Elevations range from 580 to over 1000 feet MSL.

2.79
Bedrock Geology and Stratigraphy - The bedrock geology and stratigraphy in the project area is relatively uncomplicated. The bedrock formations (Fig. E.2), Appendix E, in the project region are mainly Paleozoic in age, but included at the northwestern boundary of the Fox-Wolf River Basin are some Precambrian crystalline rocks. A generalized stratigraphic column, including lithologies and water-yielding characteristics, is presented in Table E.1, Appendix E.

2.80
The Precambrian crystalline basement rocks are exposed at the surface in a dome-like extension of the Canadian shield that is commonly called the Wisconsin dome or arch. The crystalline rocks are predominantly granite but other types of igneous or metamorphic rock may be present. The crystalline rock surface in the project region generally dips about 15 to 20 feet/mile to the southeast.

2.81
Outcropping around the flanks of this uplift are Paleozoic sedimentary formations consisting of Cambrian sandstones; Ordovician dolomites, sandstones and shale; and Silurian dolomite. This sedimentary-rock sequence conforms to the slope of the crystalline rock surface and thickens toward the southeast where successively younger rock units form the bedrock surface.

2.82
The subsequent erosion and glaciation of the edges of these strata produced a series of lowlands and northwestward facing escarpments (cuestas). The more resistant strata formed the ridge-like cuestas. Four cuestas may be recognized in going from the northwest to the southeast in the project region. These are: (1) the Cambrian sandstone cuesta, (2) the Prairie du Chien cuesta, (3) the Galena-Platteville cuesta, and (4) the Niagara cuesta. The Niagara cuesta, which forms the locally well-known cliffs (High Cliff State Park) that rise above the eastern rim of Lake Winnebago, extends into Brown and Door Counties.

2.83
Surficial Geology - Quaternary deposits include all glacial and alluvial deposits between the bedrock surface and the land surface. These unconsolidated deposits consist of clay, silt, sand, gravel, boulders, peat, marl and loess. They occur sorted or unsorted and stratified or unstratified. A map showing Wisconsin glacial deposits is presented as Figure 2.12.

2.84
Evidence of four major states of glaciation are recognized in Wisconsin.[29] Deposits laid down during the Cary and Valders substages of the Wisconsin Glaciation blanket the region and fill buried bedrock valleys. Cary deposits are gray to brown and consist of morainal, glaciolacustrine, some outwash and ice-contact deposits. Valders deposits overlie the Cary and are predominantly reddish-brown clay and silt in ground moraine and glaciolacustrine deposits laid down in this glacial lake blend with other glacial deposits and in many areas the boundary between them is indistinct. The lake deposits generally consist of stratified sand interbedded with red clay and silt.

2.85
Alluvium in the project region is generally thin. It consists of sand and gravel deposits in stream channels, peat and marl formed in marshes and lakes, and sand dunes. Thickness of the alluvium ranges from zero to over 20 feet.[24]

2.86
Seismicity - The Fox-Wolf River Basin is located in a region of relatively quiet seismic activity. It lies wholly within a zone or minor expected earthquake damage as plotted on a seismic risk map of the conterminous United States.[30]

2.87
There have been six known earthquakes having epicenters in Wisconsin, four of which were within the Lake Michigan Drainage Basin.[31] The nearest ones to the project area occurred on February 9, 1943, near Thunder Mountain, Marinette County, Wisconsin, Modified Mercali Intensity II (MM-II), and July 18, 1956, near Ootsburg, Wisconsin (MM-IV). The nearest Michigan event occurred on March 13, 1905, near Menominee, Michigan (MM-V), north of Green Bay.

Soils

2.88
The nature of the soils in northeastern Wisconsin results from the interaction of parent materials, relief, climate, plants, animals, and time. Soil differences are caused mainly by parent material and topography.[29] The principal soil series occurring in the study area are: Kewaunee, Manawa, Houghton, Poygan, Oshkosh, Rimer, Pella, Allendale and organic soils. The soils descriptions for these soils[34] are contained in Appendix E.

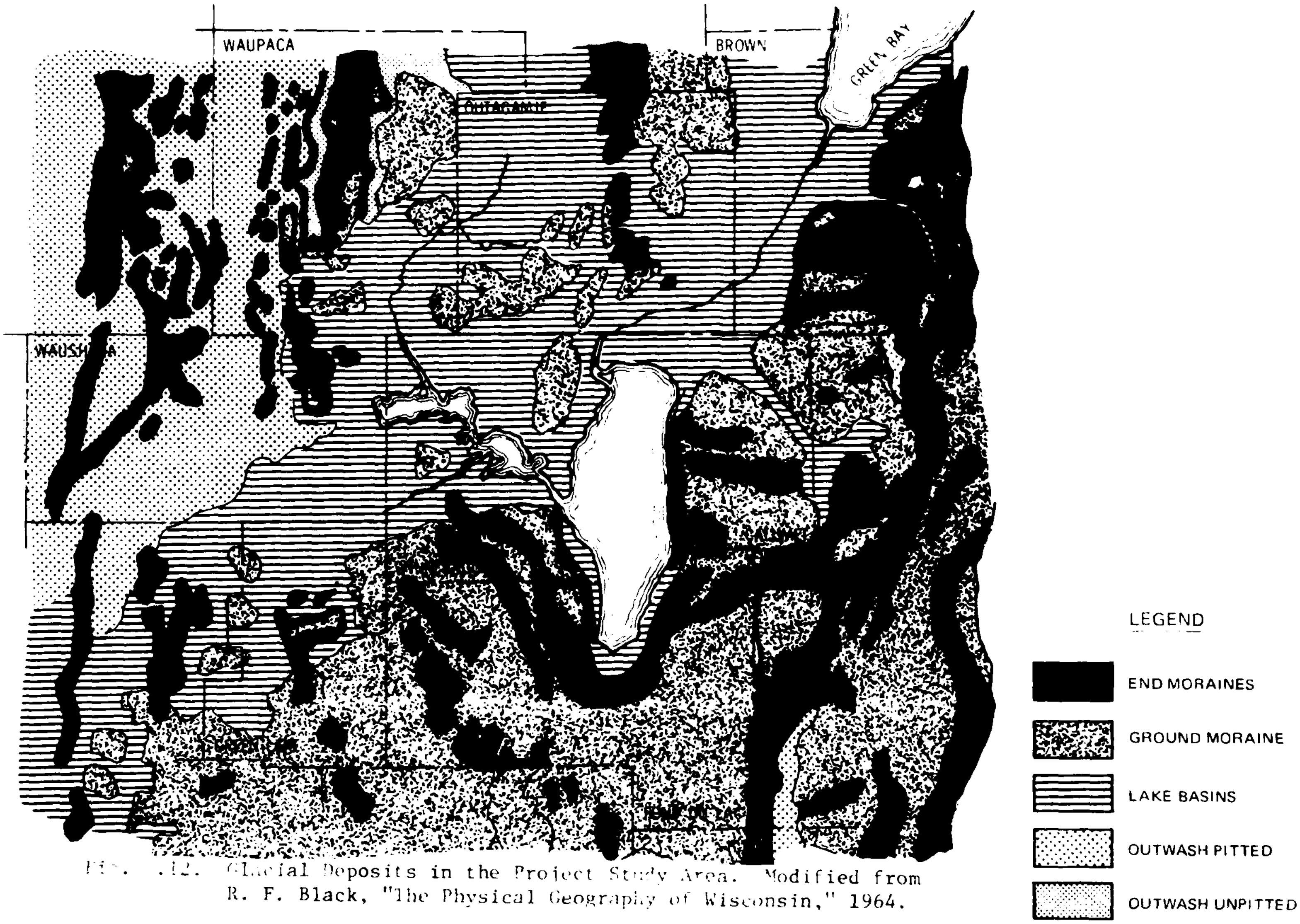

Fig. .12. Glacial Deposits in the Project Study Area. Modified from R. F. Black, "The Physical Geography of Wisconsin," 1964.

2.89
Brown County's various soil types are closely related and not easily differentiated. They are mostly derived from glacial till and outwash deposits. These are basically rich heavy soils common to gently rolling countryside. The heavy soils of Brown County are not conducive to infiltration and do not allow a large amount of water to seep into the water table. This is reflected by the general lack of springs as a water source for the county's small streams. The small streams carry heavy flows seasonally, during peak runoff periods and during heavy precipitation, but may be dry or contain stagnant water at other times.

2.90
Southern Outagamie County's soil types consist of relatively rich soils derived for the most part from glacial and silt deposits. These fertile soils are common to the gently rolling landscape, and are the reason over three-fourths of the land area is used for agricultural endeavors. Outagamie County's soils, particularly those derived from glacial drift, allow significant amounts of infiltration and as a result influence the amount of recharge to areas drained by the Fox River and local wells used by industries and municipalities. There is some spring action also recharged by this method.

2.91
For the most part, the Calumet County's soils are quite heavy, are fertile, and are will drained, making them highly desirable agricultural soils. These soils generally adversely affect the county's surface water resources. Precipitation does not readily percolate into the heavy soils and more runs off than in lighter soils. As a result there is a high runoff during periods of peak rainfall and during periods of peak snow melt and little base flow at other periods from ground water seepage. This condition leads to drastic seasonal fluctuations in stream flow and to a large number of intermittent or seasonal streams. Soil erosion is also accelerated under high flow conditions.

2.92
About 68 percent of Fond du Lac County is covered with moderately well-drained soils, predominantly silt loam, silty clay loams, and clay soils. Soils having poor drainage characteristics constitute approximately 20 percent of the total area of the county. The balance of the soils includes a variety of loamy and sandy soils.

2.93
Waushara County soils are derived primarily from the weathering of glacial drift deposits. Since these deposits are products of glacial action on the cambrian sandstones of the area the resultant soils of Waushara County are rather sandy. The county's most extensive soils are the rolling to level sands. The texture of these soils range from a sand to a sandy loam which is generally light brown in color. The eastern portion of Waushara County contains red clay soils. These have a characteristic silt loam to clay surface soil, medium brown in color. These soils are moderately well-drained and are by far the best agricultural soils found in the county.

2.94
Soils found in Waupaca County have been derived primarily from the weathering of various glacial deposits that cover the county. The most predominant soils are the red loams of eastern Waupaca County. These are moderately heavy soils ranging in color from gray-brown to red-brown. Clay substrata can be found anywhere from the surface to two feet below the surface. Natural drainage is fair. Wet, peat-muck soils are found in a band from New London to Fremont.

2.95
Small pockets of peat and muck soils are present in lowland areas throughout the project region. These soils are not well drained naturally and are not good agricultural soils.

THE HUMAN ELEMENT

Population Features

2.96
The study area includes portions of 8 counties in the upper central region of the State of Wisconsin. As shown in Table 2.4, these counties, in aggregate, experienced population growth greater than the statewide average for the period 1960-1970. Consistent with this, the region through the year 1990 is expected to increase in population at a rate faster than that projected for the state as a whole. No projections are available for years subsequent to 1990.

2.97
Generally those counties projected to grow the fastest are also those that are both the largest in terms of present population and decidedly urban in character. Included are Brown, Outagamie and Winnebago Counties. Table 2.5 lists the population centers for each of these counties, and the overall urban - non-urban relationship, which ranges from 69 percent to 79 percent of the total countywide population. This compares to less than 50 percent for the other counties in the study area. Presumably the highly optimistic population projections in part reflect this condition, out of the realization that urban areas typically have relatively broad based economies, and are therefore better able to generate and sustain high levels of growth.

Land Use

2.98
Wolf River Region of the Project Study Area - Parts of three counties comprise the Wolf River region of the project study area; Waupaca County, Waushara County, and Winnebago County. Table 2.6 gives a tabulation of the total area, land area and use, and surface water area of the counties. It should be noted that the sources of data for this table are diverse, and that measurements are from different years. Thus, only approximations could be made using the data available.

Table 2.4. Population, Observed and Projected by County

County	1960[a]	1970[a]	1974[b]	Projected[c] 1980	Projected[c] 1990
Brown	125,082	158,244	169,800	197,600	253,100
Calumet	22,268	27,604	28,100	34,000	43,600
Fond du Lac	75,085	84,567	85,800	94,900	108,800
Green Lake	15,148	16,878	17,300	18,500	20,400
Outagamie	101,794	119,356	124,100	135,300	156,600
Waupaca	35,340	37,780	39,300	39,800	42,400
Waushara	13,497	14,795	15,800	16,400	18,300
Winnebago	107,928	129,321	133,400	156,100	189,400
Total	496,142	588,545	613,600	692,600	832,600
Percent Change		18.6	4.2	12.8	20.2
Wisconsin[d]	3,455,635	3,829,186	3,934,000	4,170,600	4,606,100
Percent Change		10.8	2.7	6.0	10.4

[a] *Census of Population 1960, 1970.*
[b] *Rand McNally 1974, estimated.*
[c] *State of Wisconsin 1975.*
[d] *Wisconsin minus study area counties.*

Table 2.5. Urban Populations for Brown, Outagamie and Winnebago Counties, 1970

County	City	Population	Urban/non-urban
Brown	Allouez	13,753	
	Green Bay	87,809	
	DePere	13,309	
	Ashwaubenon	10,042	
	Total	124,733	79%/21%
Outagamie	Appleton	53,742	
	Grand Chute	6,264	
	Kaukauna	11,292	
	Kimberly	6,131	
	Little Chute	5,365	
	Total	82,794	69%/31%
Winnebago	Menasha City	14,905	
	Menasha Town	7,834	
	Neenah	22,892	
	Oshkosh	53,221	
	Total	98,852	76%/24%

Source: Census of Population 1970.

Table 2.6. Land and Water Resources in the Counties of the Fox River Project Area

COUNTY	BROWN	CALUMET	FOND DU LAC	GREEN LAKE	OUTAGAMIE	WAUPACA	WAUSHARA	WINNEBAGO	REMARKS
Total Area of County (acres)	342,489	254,718	489,600	241,900	415,273	488,310	407,680	369,900	
Land Area of County (acres)	335,600	206,300	463,900	226,800	406,000	480,300	401,500	289,900	ORIGINAL SOURCE: U.S. Bureau of Census and Water Areas of the U.S.-1960
% of Total Area	98.0	81.0	94.8	93.6	97.5	98.4	98.5	78.4	
Non-Forest Area Land Classes									
Cropland (acres)	226,800	147,900	317,400	122,100	232,200	196,400	148,000	174,500	ORIGINAL SOURCE: 1964 Census of Agriculture
Pasture & Range (acres)	8,100	[illegible]	24,600	16,400	7,800	20,000	11,400	10,600	
Marsh (acres)	--	--	27,100	35,300	10,800	37,400	25,400	13,600	
Wooded Pasture (acres)	5,400	2.700	5,400	2.700	2.700	6,800	4,600	2,700	
Other (acres)	57,700	21,900	38,800	22,200	62,600	53,300	92,800	64,400	Includes industrial and urban areas, other nonforest land and small water areas not defined as water by Bureau of Census.
Total (acres)	298,000	179,600	413,300	198,700	336,100	313,900	282,200	265,800	
Fraction of Land Area (%)	89	87	89	88	83	65	70	93	
Forest Land Classes									
Commercial (acres)	36,900	25,500	48,700	27,700	69,100	164,200	118,300	20,700	
Productive Reserve (acre)	--	800	--	--	--	400	--	--	
Unproductive (acre)	700	400	1,900	400	800	1,500	1,000	400	
Total (acre)	37,600	26,700	50,600	28,100	69,900	116,400	119,300	21,100	
Fraction of Land Area (%)	11	13	11	12	17	[illegible]	30	7	
Water Area of County (acres)	1,999	51,200	29,971	18,558	2,578	8,972	4,883	85,300	
% of Total Area	0.6	20.1	6.1	7.7	0.6	1.8	1.2	23.1	
Lakes									
Number of Lakes	23	10	42	36	33	240	136	30	
Total Area of Lakes (acres)	138	50,999	28,571	17,488	174	7,240	4,238	83,226	Areas of Winnebago, Calumet & Fond du Lac Counties adjusted by staff to include proportionate areas of Lake Winnebago.
Streams									
Number of Streams	29	15	47	58	26	74	68	19	
Total Area of Streams	1,861	300	400	1,071	2,404	1,732	646	2,074	
% Land plus % Water	98.6	101.1	100.9	101.5	98.4	100.2	99.7	101.5	
Unresolves Difference (%)	1.4	-1.1	-0.9	-1.5	-1.6	-0.2	-0.3	-1.5	

Land area for Brown County from "Wisconsin Forest Resource Statistics-Lake Michigan Survey Report," Wisconsin Department of Natural Resources, Madison. 1968.

Land area for other counties from "Wisconsin Forest Resource Statistics-Lake Winnebago Survey Report," Wisconsin Department of Natural Resources, Madison. 1968.

Water area for all counties from "Surface Water Resources of (County name) County," Wisconsin Department of Natural Resources, Madison. Dated over period 1969 to 1971.

Total area for all counties from J. H. Marter and R. N. Cheetham, Jr. "Areal Measurement and Nomenclature of the Watersheds in the Southeast Wisconsin River Basins," U. S. Department of Agriculture, Soil Conservation Service. 28 pp. September 1971.

Forest land information from "Forest Area in Wisconsin Counties-1968," U. S. Department of Agriculture, North Central Forest Experiment Station, Forest Service, 4 pp. 1972.

2.99
Waupaca County is primarily an agricultural county.[36] Recreation and industry are making inroads into the economic structure of this agricultural stronghold, however.[36] Primary industries are dairy farming and cropping but manufactured products include trucks, trailers, campers, foundry products, and plywood products.[37] Numerous canning plants, milk and cheese processing plants, and lumber mills are also located in the county.[37]

2.100
87 of the 340 miles of streams in Waupaca County are listed as trout streams.[106] The Wolf River in Waupaca County, particularly around Fremont, is well known for its spring runs of Walleye and White Bass.[37,38] The county is also popular as a vacation area and lists boating, fishing, snowmobiling, hunting, and canoeing as its recreational attractions.[37,38] In promotional literature, the county is described as having a "clean environment, a small town way of life."[37]

2.101
The farms in the county are generally small, family-owned and operated, and provide work and housing for about 6000 people (about one-sixth of the county population).[37] Seasonal "second homes" ownership is common within the county.[38]

2.102
Only three cities in the county (Clintonville, New London, and Waupaca) have populations of greater than 2500 people and none of the three has populations in excess of 5000 people.[39]

2.103
Waushara County, like Waupaca County, is primarily an agricultural county. It has the smallest population and smallest population density of the eight counties in the project study area. No cities in the county have a population of as many as 2500 people. Therefore, only those residents of the city of Berlin (Green Lake County) who are situated in Waushara County are listed as urban residents.[39]

2.104
Total area, land area and use, and water area are shown in Table 2.6. Because of the dominant rural nature of the county and the comparatively small population (14,795 in 1970[39]) to support such activity, no comprehensive county plan or current descriptive literature about the county has been produced. The county activities, planning, life style, etc., are primarily oriented toward agriculture. Recreation and tourism are important sources of revenue.

2.105
None of the project activities occur in Waushara County itself and all watersheds of the county are upstream of the project activities. Therefore, the land use impacts of this county have not been considered in depth.

2.106
Winnebago County forms the connecting link between the Wolf River region, the the central or lake region, and the Fox River region of the project study area. The total area land area and uses, and water area of the county are shown in Table 2.6. Surface water is generally the prime factor in the success of recreation in the project study area. Winnebago County with its several very large to large lakes (Lakes Winnebago, Poygan, Butte des Morts, Winneconne, Rush, and Little Butte des Morts) is a prime area for water-related activities such as boating, water skiing, fishing and swimming.

2.107
The major Winnebago County population centers (and their respective populations[39]) are: Oshkosh (53,221), Neenah (22,892), and Menasha (14,905) and the towns of Menasha (7,834), Oshkosh (4,943), Neenah (3,719) and Algoma--the town which contains part of the city of Oshkosh--(3,158). All of these places are urbanized, industrial areas.

2.108
Winnebago County is primarily an urbanized county dominated by the activities of the Oshkosh and Neenah-Menasha areas. Secondarily, the county is a recreation and tourist area dominated by the water related activities of Lake Winnebago and the connected Lakes Butte des Morts, Winneconne, and Poygan. However, away from the urban areas and the lakes, the county possesses a strong agricultural character. Close to the lakes, but away from the urban areas, seasonal "second homes" ownership is common and recreational activities predominate.

2.109
<u>The Central or Lake Region of the Project Study Area</u> - The central or lake region of the project study area consists of parts of the following counties: Waushara, Green Lake, Winnebago, Fond du Lac, and Calumet. Both Waushara and Winnebago Counties are described above.

2.110
Green Lake County is primarily an agricultural county. Its inclusion as a county in the study area is required because an estimated 1862 acres is contained in the Lake Butte des Morts watershed.[40] However, this county, like Waushara County, contains no areas where project activities are proposed and it lies totally upstream of all such activities. Total area, land area and use, and water area data have been included for Green Lake County in Table 2.6. Land-use impact consideration of this county was not made because of its postulated freedom from project impacts.

2.111
Fond du Lac County has two distinct characters: a local urban setting is found along the south shoreline of Lake Winnebago while the remainder of the county is agricultural in character. The area adjacent to Lake Winnebago contains the City of Fond du Lac and two towns. The 45,389 inhabitants of these political subdivisions comprise about 53.7% of the entire Fond du Lac County population. Although this area has some industry, it is less industrialized than the Oshkosh area and the Neenah-

Menasha area noted above, or the Lower Fox River Valley region which is discussed subsequently. Table 2.6 shows the total area, land area and use, and water area data for this county.

2.112
Calumet County is primarily agricultural in character, although four small urban communities are found in the county. The urban areas (and their respective populations[39]) are: the relatively small Calumet County area of the City of Appleton (3401), Brillion (2588), Chilton (3030), and New Holstein (3012). The fact that these four small but separated cities contain about 34% of the total population of the county, attests to the rural nature of the county. In 1970 the crop and pasture lands occupied 77% of the county's land area, land developed for nonagricultural purposes occupied only 5%, and forested land and wetlands made up 13%.[40] Although much of the land use in Calumet County along Lake Winnebago is of a permanent rather than seasonal nature, recreation is a land use with a great deal of potential.[41]

2.113
<u>The Fox River Region of the Project Study Area</u> - Portions of Brown and Outagamie Counties comprise the Fox River Region of the project study area. From a land-use standpoint the majority (65%) of Outagamie County is agricultural land (see Table 2.6). From a population standpoint, however, the majority of the population (69%) is urban and the area is largely industrial in character. The industrial area of the county is located along the Fox River and includes the cities of Appleton, Kimberly, Combined Locks, Little Chute, and Kaukauna. Little industrial activity is found along the Fox River in the area downstream of Kaukauna to the Outagamie-Brown County line. Outside of the urbanized areas bordering the Fox River, little industrial activity is found in Outagamie County and the county is agricultural in character.

2.114
Water-related recreational activity in Outagamie County is largely limited to the Wolf River and Embarras River areas upstream from New London in the northwest section of the county even though boaters have relatively easy access to the Fox River from urbanized areas. This is due in part to the poor water quality of the Lower Fox River. From the launching sites on the Fox River the boaters can move upstream to Lake Winnebago or downstream to Green Bay by using the project's lock system. Use of the lock system from Appleton, particularly in the downstream (Green Bay) direction, is time consuming, however, because of the large number of locks.

2.115
Brown County is the northern-most county in the project study area and together with Outagamie County comprises the majority of the shoreline of the Lower Fox River between Lake Winnebago and Green Bay. Brown County, like Outagamie County, is primarily agricultural (72%) from the land-use point of view (see Table 2.6), and also a majority (82%) of its population is urban. This urban population resides primarily in and around the City of Green Bay, whose industrial activity is the dominant force in establishing the character of the county.

2.116
Historically, the Green Bay area of Brown County developed in support of the Great Lakes-to-interior Wisconsin supply route along the Fox River. Both the industrial rail-shipping spine[42] and the commercial barge traffic on the Lower Fox River were key elements in this development. With the advent of modern commercial highway transportation the commercial barge traffic became obsolete due to the small barge size and tonnage. Green Bay, however, remains a prime industrial city and commercial port on Lake Michigan and serves the central region of Wisconsin.

2.117
Except for the Green Bay urban industrial area, the remainder of Brown County is rural and the primary land use is devoted to small, family-owned farms. Water-related recreational activities are primarily centered in the bay which is a popular resource for all water-related activities. Commercial port facilities in the city of Green Bay make the city a freshwater seaport. These facilities are largely responsible for the city of Green Bay's local prominence in industry, commerce, and transportation.

Water Use

2.118
The water resources of the Fox-Wolf region are used extensively throughout the project region. Major flow uses include navigation, hydroelectric power generation, waste water dilution, and certain types of recreation. More important withdrawal uses of the water resource include domestic and industrial uses. Each of these uses affects the quantity and/or quality of the water resource.

2.119
Navigation - The locks of the Lower Fox River system, which were originally designed for commercial navigation, are now used almost entirely for movement of recreation craft into Lake Winnebago and Green Bay. Principal avenues of recreational navigation are: the Lower Fox River, the Winnebago Pool and the Wolf River channel from Lake Winnebago to New London. The generally upward trend of this use is apparent from usage statistics which show that traffic of craft between the Menasha Locks and Lake Winnebago nearly doubled during the period 1960 to 1975. It is anticipated that non-commercial traffic on the waterways will continue to increase.

2.120
Recreation - The regions water resources have assumed rapidly increasing importance as a major focus for recreational activities, particularly fishing, hunting, and boating. These activities are making increasing claims to the use of the region's lakes, streams, and wetlands. Not only have there been numerous conflicts between recreation and other potential water uses, but there have also been conflicts between various types of recreational activities, such as fishing and power boating. The intensity of boating use primarily for fishing, pleasure cruising, and water skiing in the project area is concentrated around the larger lakes having adequate launching facilities and access. Because of its size and

character, Lake Winnebago provides the widest range of boating opportunities. Minor, short-term congestion occurs occasionally at the locks along the Fox River. Crowded conditions are evident along the Wolf River, especially during the spring walleye runs. The intensity of boating will continue to increase at a rapid rate in the region, bringing increased demands for mooring facilities and associated services. It will also give rise to further conflicts in water use. Major conflicts have also arisen over the preservation of wetlands for fish and wildlife habitat, and their development for agricultural purposes.

2.121
Hydroelectriac Power - The Fox, as a primary source of power, is much less important today than it was in the past. Historically, the operation of hydroturbines at dam sites along the Lower Fox River was an important factor in the development of the region and is summarized in Table 2.7. However, because of the present marginal value of power generated, a large percentage of existing hydropower generating capacity is used to serve for peaking power purposes. Also, the number of electrical power generation stations in operation on the Lower Fox River has been decreasing over the years. The common situation has been that when a turbine-generator unit breaks down it is not repaired since power can be purchased elsewhere at less than the repair cost. There are presently between 12 and 15 separate generating stations in operation. Table 2.7 summarizes the information obtained on these stations. The installed flow capacities reflect both electrical power generation and mechanical drives for other purposes. The owners of the power stations can be divided into three classes: industrial, publicly owned utility, and privately owned utility. They produce electricity for commercial, residential, and industrial use. In some cases power is produced exclusively for an individual company while in other cases it is sold to various users.

2.122
Domestic and Industrial Water Supplies - Demands for domestic and industrial water supplies in the region are growing steadily, and although the region as a whole has ample resources to meet these demands, shortages may arise in some parts of the region. The growth in municipal water demands has been especially great in the larger cities, notably Oshkosh and Appleton. Most of the water used by industry in the region is accounted for by pulp and paper manufacturers. It is not possible on the basis of data currently available to estimate present and future overall municipal and industrial water use requirements for the region. Much more penetrating studies would be required.

2.123
About 20 percent of all the water withdrawn in the region is withdrawn by public water utilities and by local government bodies for domestic water supplies, commercial uses, and certain industrial uses, and for such purposes as fire-fighting, street-washing, and so on.[40] Four communities (Appleton, Oshkosh, Neenah, and Menasha) depend on surface water supplies; others depend primarily on groundwater. In most cases some treatment is required, particularly where water for drinking purposes is involved.

Table 2.7. Electrical Power Generation on the Lower Fox River

Dam	Power Station Owner	Owner Class*	Turbine Flow Capacity CFS	Generator Capacity KW	Number of Turbines
Neenah	Bergstrom Paper Co.	I	0	0	
Menasha	George A. Whiting Paper Co.	I	**	250	2
Upper Appleton	Wisconsin-Michigan Power Co.	U	1980	1440	3
Upper Appleton	Kimberly-Clark Corp.	I	2300	1650	3
Middle Appleton	Appleton Woolen Mills	I	0	0	
Middle Appleton	Fox River Paper Corp.	I	2100	1315	7
Lower Appleton	Foremost Dairies, Inc.	I	**	120	2
Lower Appleton	Consolidated Papers, Inc.	I	**	480	**
Kimberly	Kimberly-Clark Corp.	I	4000	1600	3
Little Chute	Kaukauna Electric and Water Dept.	P	**	3300	3
Combined Locks	Appleton Papers, Inc.	I	2370	2890	7
Upper Kaukauna	Kaukauna Electric and Water Dept.	P	4000	5600	4
Lower Kaukauna	Kaukauna Electric and Water Dept.	P	**	2400	4
Rapide Croche	Kaukauna Electric and Water Dept.	P	**	2400	4
DePere	Nicolet Paper Corp.	I	**	1122	**

Source: Special Report #503, University of Wisconsin, Sea Grant College Program.

** I=Industrial, P=Publicly Owned Utility, U=Privately Owned Utility*

***Not able to obtain information.*

Less than 10 percent of the water withdrawn for public water supplies is consumed; the remainder returns to streamflow after use.[40]

2.124
The Lower Fox River area is the most industrialized region in the project area. There is a heavy development of paper mills resulting in the greatest concentration of pulp and paper industry in the state. Considerable use is made of the stream for industrial and cooling water supply.

2.125
Waste Dilution and Removal - The rivers and lakes of the region are also used for diluting and removing wastes from municipalities and industries. The most intensive use of the region's water resources for these purposes is along the shores of Lake Winnebago and the Lower Fox River. As a general rule, one cubic foot per second (1 cfs) of river water will satisfy a waste loading of 26 lbs BOD. The mean flow of the Lower Fox River is 4139 cfs, implying a capacity to satisfy a BOD loading of about 98,000 lbs. Sometimes the BOD loading is in excess of this amount. Moreover, flows considerably less than 4139 cfs are experienced on the Lower Fox River at times. Accordingly, serious problems of waste disposal are experienced. Other streams in the region are also used for waste dilution and disposal, notably the Wolf River. Waste loadings, however, have been relatively minor in comparison with those in Lake Winnebago and along the Lower Fox River.

Development and Economy

2.126
Agriculture - In the period 1964-1969, the number of farms and total farm acreage in the region decreased slightly. However, the average acreage per farm increased. This trend has been noted on a national level. Table 2.8 displays selected agriculture statistics for the 8-county region. With the exception of Waukesha County, the vast majority of the farm based revenues were generated by livestock, poultry and allied products. Within this general category, dairy products were the prime revenue producers. Of the cash crops, corn, hay and oats were the main sources of revenue.

2.127
Manufacturing - During the period 1967-1972, the number of manufacturing firms in the region decreased slightly as did the level of sectoral employment. However, individually several counties experienced sizeable increases in manufacturing employment, the most notable being the 8 percent increase in Brown County. At the same time, the number of workers in this sector decreased by about 9 percent in Winnebago County. The stability of manufacturing employment for the region relative to the state as a whole is evidenced by the increase in share attributed to the region over the period of measure. This is also reflected in the regions increasing share of statewide value added in manufacturing. In absolute terms, the largest contributor to this category was Brown County ($383,600,000). The major manufacturers in the county produce paper products, construction machinery and cheese. Fond du Lac County recorded

Table 2.8. Selected data, agriculture, 1964 and 1969

County	Number of farms 1964	Number of farms 1969	Revenue, 1969[a]	Livestock, poultry as percent total revenue
Brown	2,172	1,886	$ 30,400,000	91.6
Calumet	1,493	1,331	22,900,000	91.9
Fond du Lac	2,768	2,429	48,700,000	86.1
Green Lake	961	877	17,000,000	86.4
Outagamie	2,494	2,140	34,800,000	89.9
Waupaca	2,230	1,974	24,600,000	90.2
Waushara	1,182	983	15,100,000	56.8
Winnebago	1,597	1,349	20,700,000	87.5
Total	14,892	12,969	$215,200,000	
Percent of State	12.5	13.1	13.1	12.9

[a] *1972 prices.*

Source: Census of Agriculture, 1969, 1964.

the largest percentage change in value added between 1967 and 1972 (38 percent). Major products manufactured there are outboard motors, machine tools, and laundry equipment. Only one of the 8 counties, Waushara, experienced a decrease in value added (45 percent). Selected data pertinent to the manufacturing sector are shown for all study area counties in Table 2.9.

2.128
Retailing - The retail sector includes among others auto dealers, food, drugs, department and furniture stores. During the period of record, 1967-1972, retail sales for the above establishments in the region increased 17.5 percent (constant dollars). This compares to the 9.5 percent increase recorded statewide. As a result the regions share of retail sales as a percent of the state total increased from 13.4 percent in 1967 to 14.3 percent in 1972, a change of 6.7 percent. Individually, the counties registering the largest sales gains were Brown (25.3 percent) and Green Lake (23.6 percent), the smallest, Fond du Lac (8.8 percent). Of the eight, only Calumet recorded a decline (1.5 percent). Consistent with the real increase in sales, the number of people employed in this sector also grew during the period 1967-1972. This, along with other pertinent data is shown in Table 2.10.

Table 2.9. Selected Data, Manufacturing, 1967, 1972

County	Number firms 1967	Number firms 1972	Number employed 1967	Number employed 1972	Value added (000) 1/ 1967	Value added (000) 1/ 1972
Brown	253	251	16.2	17.5	$ 321,900	$ 383,600
Calumet	61	58	4.3	4.5	66,200	87,200
Fond du Lac	129	129	10.4	10.8	171,800	237,100
Green Lake	42	43	2.1	2.0	26,700	29,300
Outagamie	188	175	13.6	14.2	220,000	281,400
Waupaca	101	93	3.5	3.4	38,600	51,500
Waushara	15	18	.6	.3	6,600	3,600
Winnebago	243	239	21.6	19.7	308,800	355,300
Total	1,032	1,006	72.3	72.4	$1,106,000	$1,429,000
Percent of State	13.1	12.8	14.1	14.4	14.5	15.1

1/ *1972 dollars.*

Source: Census of Manufacturers, 1967, 1972.

Table 2.10. Selected Data, Retailing, 1967 and 1972

County	Number firms 1967	Number firms 1972	Number employed 1967	Number employed 1972	Sales (000)[a] 1967	Sales (000)[a] 1972
Brown	1,383	1,479	8,511	10,675	$ 301,700	$ 378,300
Calumet	297	325	895	1,023	39,200	38,400
Fond du Lac	939	931	4,440	5,264	164,900	179,500
Green Lake	272	257	825	1,165	38,400	47,500
Outagamie	1,100	1,141	6,447	7,382	225,000	266,000
Waupaca	646	607	1,618	1,919	68,600	76,300
Waushara	212	227	440	476	20,700	24,800
Winnebago	1,143	1,229	6,754	8,034	223,700	259,900
Total	5,992	6,196	29,930	35,938	$1,082,200	$1,270,700
Percent of State	13.3	13.4	13.9	14.2	13.4	14.3

[a] *1972 dollars.*

Source: Census of Retailing 1967, 1972.

2.129
Mining - Statewide the value of mineral production, in real terms, has decreased between 1967 and 1972. This trend has also been observed for the eight county study area. In the latter, the decrease in real value of output amounted to $1,840,000 or 19.6 percent. In dollar terms, the largest producers were Fond du Lac and Winnebago counties, the predominant minerals extracted were stone, sand and gravel. Table 2.11 summarizes, for purposes of comparison, data for 1967 and 1972.

Transportation

2.130
Highway - The eight county study area is characterized by a well developed highway system, which permits easy access to all points in the region. The major facility, U. S. Highway 41, serves the larger cities in the study area and provides an essentially unobstructed route from them to both Chicago and Milwaukee.

2.131
Railroads - The area is served by four railroads: Chicago and Northwestern, Soo Line, Green Bay and Western, and the Milwaukee Road. The bulk of the service provided by these railroads is freight oriented.

Table 2.11. Selected Data, Mining, 1967 and 1972

County	Value of Output (000)[a] 1967	1972	Minerals produced[b]
Brown	$1,568	$ 98	Lime, stone, sand & gravel
Calumet	325	W	Stone, sand and gravel
Fond du Lac	2,138	W	Stone, sand and gravel
Green Lake	724	397	Stone, sand and gravel
Outagamie	770	W	Stone, sand and gravel
Waupaca	464	186	Stone, sand and gravel
Waushara	131	87[c]	Stone, sand and gravel
Winnebago	3,265	2,242	Stone, sand and gravel
Total	$9,386	$7,546	
Percent of State	9.2	8.4	

Source: Minerals Handbook 1967, 1972.

[a] *1972 dollars.*

[b] *In order of value.*

[c] *1971 data.*

2.132
Air - Three commercial airports are within the eight county study area. These are located at Green Bay, Oshkosh and Appleton. North Central Airlines maintains regularly scheduled flights to Green Bay and Oshkosh, Air Wisconsin to Appleton.

2.133
Water - Water transportation is possible from Green Bay to Lake Winnebago via the Lower Fox River and from Lake Winnebago to New London and beyond via the Upper Fox River and Wolf River. From Green Bay to Lake Winnebago, water transportation is generally limited by the channel depth (six feet below standard low water level but 5.5 feet in the locks), the small lock sizes (144 feet long by 35 feet wide usable space), and the large number of locks (17). The latter results in a minimum lockage time of about 4.25 hours for a one-way trip.[10] From the Menasha lock to the mouth of the Wolf River in Lake Butte des Morts, navigation channels are also maintained to a channel depth of 6 feet below standard low water level. The navigation channel in the Wolf River from its mouth at Big Lake Butte des Morts to New London, a distance of 47 miles, is generally maintained to a channel depth of 4 feet below standard low water.

Recreation Features

2.134
The forms of recreation that fall within the perview of this report are boating, canoeing, fishing, hunting, swimming, camping, picnicking, sightseeing, nature study, and several winter sports. Accordingly, the following discussion will concentrate on the above, from both a facility supply and usage standpoint. Since boating and fishing are the recreational activities most directly affected by project operation and maintenance, these activities have been given the most attention.

2.135
Boating - Recreational boating is use of the more popular form of outdoor recreation in the 8-county area. This is evidenced by the dramatic increase in boat registrations recorded in the period 1970-1974 which is shown in Table 2.12. Comparison of this table with Table 2.4, which shows the observed and estimated population for the region, indicates that boat registrations have increased more than in proportion to population changes. Whereas in 1970 one boat was registered per 14.6 persons, in 1974 one boat was registered for each 12.2 persons. In both instances the density of boat ownership is slightly greater than that recorded for the state as a whole.

2.136
Boating, Harbor Facilities - Table 2.13 summarizes the harbor facilities available to boaters on Lake Winnebago, the Lower Fox River and the Upper Fox and Wolf Rivers. This data, published in 1968, represents the last comprehensive survey of facilities in the region.[10] However, in view of the marked increase in regional boat ownership, it is reasonable to believe that the number of recreational navigation facilities has grown through time.

Table 2.12. Boat Registration by County, 1970 and 1974[a]

County	Registered Boats 1970	Registered Boats 1974	Percent Sailboat 1970	Percent Sailboat 1974
Brown	8,727	11,605	2.0	2.8
Calumet	1,506	2,024	1.3	1.8
Fond du Lac	4,403	5,503	2.0	2.4
Green Lake	2,269	2,470	1.4	2.6
Outagamie	7,711	9,983	1.4	2.1
Waupaca	4,365	5,074	.5	.6
Waushara	1,298	1,618	1.0	1.4
Winnebago	10,117	12,244	2.3	2.8
Total	40,396	50,521		
Percent of State	14.4	14.5	11.9	13.7

[a]*All figures are end of year values.*

Source: State of Wisconsin, Department of Natural Resources.

Table 2.13. Harbor Facility Inventory, 1968

Area	Slips	Moorings	Dry Sail	Launch Lanes[a]
Lower Fox	210	50	-	3
Lake Winnebago	613	175	178	24
Upper Fox/Wolf	410	125	175	14
Total	1,233	350	353	41

[a]*Excludes (1) gravel or wood launch lanes, (2) privately owned launch lanes, and (3) launch lanes associated with insufficient parking.*

2.137
Boating, Seasonal Usage Pattern - A study completed in 1974, the Lake Michigan Regional Boating Study (LMRBS), by the Chicago District surveyed boat use patterns for launched and permanently berthed boats 16 feet or greater in both the Lake Winnebago and Lake Michigan areas.

2.138
The study found that while recreational boat launching in the Lake Winnebago area typically spans an 8-month season, 87 percent of the activity occurs in the months of May (16 percent), June (25 percent), July (27 percent), and August (19 percent). During the peak boating months of July, 81 percent of the activity was recorded on Saturday (52 percent) and Sunday (29 percent). Weekday usage ranged from 1 percent (Monday) to 7 percent (Friday). Analysis of the launch frequency by hour of the day for July indicates that 60 percent occur between the hours of 7 a.m. and 12 noon, and averages between 5-6 hours in duration.

2.139
The LMRBS found that the seasonal usage for permanently based boats varied by boat size and type of storage. Table 2.14 illustrates this variation by comparing boats kept in water, berthed, to those stored on land, dry. When compared to the launched boat data, it indicates a markedly different pattern of use. Analysis of weekly trip frequency during the month of July shows the majority of usage occurring on weekends. However, weekend use is less intensive than that estimated for launch boats. The data is summarized in Table 2.15. During a typical day in July the majority of the departures occur between the hours of 9 a.m. and 2 p.m., a significant departure from that which was observed for launched boats. Part of this discrepancy can be traced to the nature of use of launch boats versus permanently stored boats. The former are assumed to remain in the general vicinity of the harbor from which they were launched. As stated earlier, a launch boat outing would typically span 5-6 hours. In the latter, the LMRBS found that about 35 percent of trips taken by permanently based boats involved a stop at a harbor other than the home port harbor. Thus, the extended nature of trips in this cateogry would be reflected in later arrival and departure times. Table 2.16 summarizes the survey results pertaining to permanently based boat departure times.

2.140
Peak Day Boating Use - Lake Winnebago; Launched Boats - The LMRBS concluded that the typical launch land located on Lake Winnebago accommodated about 2,000 launches during 1971. If the launches per lane were assumed to increase proportionally to the growth in the boat fleet, 1974 per lane launches could be estimated at 2,380. Based on the facility inventory discussed earlier, a total of 57,120 boats would have been launched on Lake Winnebago in 1974. As will be recalled, about 27 percent of annual launch boat activity takes place during the month of July. Further, 52 percent of that activity occurs on Saturdays. Employment of this information makes it possible to estimate peak day launch boat activity on Lake Winnebago. This is done in Table 2.17, and results in estimated peak day usage of 2,005 boats.

Table 2.14. Seasonal Use Pattern (percent)

Storage Type	Before May	May	June	July	Aug.	Sept.	Oct.	After October
Berth 16-25'	4.1	8.2	17.2	22.8	23.9	16.4	6.5	.9
Berth over 25'	2.5	8.2	19.1	22.4	21.1	17.9	7.6	1.2
Dry 16-25'	4.3	8.3	14.7	21.8	26.4	16.0	8.3	.3
Dry over 25'	7.1	10.6	19.2	20.5	18.9	14.6	7.6	1.6

Source: LMRBS, 1974.

Table 2.15. Weekly Use Pattern, July (percent)

Storage Type	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
Berth 16-25'	11.3	4.6	3.5	2.0	8.0	31.7	38.9
Berth over 25'	5.9	5.4	7.1	3.1	10.5	31.7	30.1
Dry 16-25'	.6	1.1	7.3	2.8	3.4	52.8	32.0
Dry over 25'	5.7	3.0	10.7	4.5	9.6	35.5	31.0

Source: LMRBS, 1974.

Table 2.16. Departure Times, Permanently Based Boats (percent)

(1) Berthed, Moored, and Dry Stored 16-25'

Hour	1	2	3	4	5	6	7	8	9	10	11	12	Total
AM	3.8	0	.7	0	.1	0	1.1	2.0	7.0	13.7	12.5	8.8	54.7
PM	13.1	10.9	.6	10.4	4.1	4.2	2.4	2.4	.4	.4	0	0	45.3

(2) Berthed, Moored, and Dry Stored over 25'

Hour	1	2	3	4	5	6	7	8	9	10	11	12	Total
AM	1.3	0	0	0	.2	.8	3.3	4.0	8.9	10.3	15.3	6.0	50.1
PM	9.1	8.8	5.1	4.3	4.2	5.9	4.7	3.5	2.2	1.2	.5	.3	49.9

Source: LMRBS, 1974.

Table 2.17. Derivation of Peak Day Use, Lake Winnebago

1.	Boats launched annually	57,120
2.	July activity as percent of total	x .27
3.	Launches during July	15,422
4.	Activity on Saturday as percent of total	x .52
5.	Launches on Saturday	8,020
6.	Adjustment for given Saturday	x .25
7.	Estimated peak day use	2,005

2.141
Permanently Based Boats - If it is assumed that (1) all harbor facilities designed for the use of permanently based boats are used to capacity, and (2) the aggregate facilities available have increased proportional to overall changes in boat registration, then about 1,150 berths are presently available. Further, it was noted earlier that about 22 percent of total use with regard to permanently based boats occurs in July, and that at minimum 32 percent of the activity originates on Saturdays. From this information, it is estimated that about 506 boats use Lake Winnebago on a peak day. The derivation is shown in Table 2.18.

2.142
Peak Day Boating Use - Upper Fox and Wolf Rivers - The same procedure as that discussed above was employed to estimate peak day use on the Upper Fox and Wolf Rivers. In total, 1,541 boats of which 1,169 are launch boats are estimated to use these rivers on a peak day. The computations are summarized in Tables 2.19 and 2.20.

2.143
Peak Day Boating Usage - Lower Fox River - The derivation of Lower Fox River peak day usage was undertaken as above and resulted in estimated use of 100 launched boats and 136 permanently stored boats. The computations are shown in Tables 2.21 and 2.22.

2.144
In summary the estimated systemwide peak day and seasonal usage for boats 16 feet or greater in length is shown in Table 2.23. No allowance for boats smaller than 16 feet has been made, because of the lack of reliable data pertaining to their use patterns. Further, no distribution of these boats by functional use is known.

2.145
A spot survey of boat usage by size was undertaken one Sunday in June 1975 for both Lake Winnebago and the Upper Fox and Wolf Rivers. The Lower Fox River was not surveyed. While no degree of statistical reliability can be attached to the survey results, they are included in this report for illustrative purposes. They indicate that 25 percent of total usage on Lake Winnebago, and 50 percent of total usage on the Upper

Table 2.18. Derivation of Peak Day Use, Lake Winnebago

1.	Boats permanently based	1,150
2.	Number of trips taken annually 1 boat	x 25
3.	Total trips taken annually	28,750
4.	July activity as percent of total	x .22
5.	Trips during July	6,325
6.	Activity on Saturday as percent of total	x .32
7.	Trips on Saturday	2,024
8.	Adjustment for given Saturday	x .25
9.	Estimated peak day use	506

Table 2.19. Derivation of Peak Day Use by Launched Boats, Upper Fox and Wolf Rivers

1.	Boats launched annually	33,320
2.	July activity as percent of total	x .27
3.	Launches during July	8,996
4.	Activity on Saturday as percent of total	x .52
5.	Launches on Saturday	4,678
6.	Adjustment for given Saturday	x .25
7.	Estimated peak day use	1,169

Table 2.20. Derivation of Peak Day Use by Permanently Based Boats, Upper Fox and Wolf Rivers

1.	Boats permanently based	845
2.	Number trips taken annually per boat	x 25
3.	Total trips taken annually	21,125
4.	July activity as percent of total	x .22
5.	Trips taken during July	4,648
6.	Activity on Saturday as percent of total	x .32
7.	Trips on Saturday	1,487
8.	Adjustment for given Saturday	x .25
9.	Estimated peak day use	372

Table 2.21. Derivation of Peak Day Use by Launched Boats, Lower Fox River

1.	Boats launched annually	2,856
2.	July activity as percent of total	x .27
3.	Launches during July	771
4.	Activity on Saturday as percent of total	x .52
5.	Launches on Saturday	400
6.	Adjustment for given Saturday	x .25
7.	Estimated peak day use	100

Table 2.22. Derivation of Peak Day Use by Permanently Based Boats Lower Fox River

1.	Boats permanently based	309
2.	Number trips taken annually per boat	x 25
3.	Total trips taken annually	7,735
4.	July activity as percent of total	x .22
5.	Trips taken during July	1,702
6.	Activity on Saturday as percent of total	x .32
7.	Trips on Saturday	545
8.	Adjustment for given Saturday	x .25
9.	Estimated peak day use	136

Table 2.23. Summary of Estimated System Use 1974[a]

Area	Peak day	Seasonal
Lake Winnebago	2,511	85,870
Upper Fox and Wolf Rivers	1,541	54,445
Lower Fox River	236	10,591
Total	4,288	150,906

[a] *Boats 16 feet or greater.*

Fox and Wolf Rivers can be associated with and expected from boats less than 16 feet in length. If these relationships were borne out in subsequent studies, this would suggest that only 63 percent of total usage in the above areas was accounted for in the analysis of boats 16 feet or greater.

2.146
After an analysis of pertinent data, i was concluded that aggregate seasonal usage by recreational craft in the Lower Fox River would approximate the 10,591 occasions estimated earlier. Put alternatively, it is thought that only an insignificant number of boats smaller than 16 feet in length utilize the bulk of facilities on the Lower Fox River.

2.147
Table 2.24 summarizes lockage statistics for recreational and commercial craft for the period 1972-1975. As can be seen, the greatest frequency of lockages occurs at the locks closest to Lake Winnebago and Green Bay. This indicates that a number of boaters utilize the launching or storage facilities on the Lower Fox, but actually boat elsewhere.

2.148
The data also show that the maximum number of boats that transited the whole Lower Fox system on an annual basis is quite low, ranging from 288 in 1973 to 388 in 1974. This can be directly attributed to the number of locks involved in complete transit (17) - the majority of which are in close proximity to each other, and the time consuming nature of the process (in excess of 4 hours).

2.149
For 1974, the last year in which complete pertinent recreational boating data was available, 19,570 craft were involved in lockages. After adjustment for round trips and non-recreational traffic, Lower Fox River work related usage was found to be 9,284 boats. If a reasonable level of intrà-pool use (use not reflected in lockage statistics) is considered (several pools are sufficient to support this), this result is consistent with the usage estimated for boats in excess of 16 feet in length and aggregating to 10,591 boats annually.

2.150
Canoeing - Some 200 miles of the project region streams are officially designated canoe streams, and other canoeing opportunities exist. Many of the lakes and tributaries to the major river can be canoed, at least on an intermittent basis. The use of highly powered pleasure craft on the Wolf and Fox Rivers is having a negative effect on both canoeing and shoreline stability. As a result the majority of resident canoeing participation occurs in the northern areas of the state which have better water quality and forested environments. Improvements in water quality in the region's rivers and protecting their shorelines could improve canoeing opportunities, especially on the Fox and Wolf systems.

Table 2.24. Lockage Statistics 1972-1975, Lower Fox River

Lock	1972		1973		1974		1975	
	Lockages	Craft	Lockages	Craft	Lockages	Craft	Lockages	Craft
Menasha	2,313	3,743	2,707	4,289	2,567	4,214	2,552	4,200
Appleton 2nd	447	653	434	671	542	847	542	864
Appleton 3rd	444	648	434	670	542	849	542	864
Appleton 4th	448	640	451	693	553	852	542	844
Cedars	462	634	421	638	552	838	583	883
Little Chute 2nd	441	613	403	621	513	806	519	824
L. C. Combined (Upper)	448	618	401	621	506	778	499	774
L. C. Combined (Lower)	448	618	401	621	506	778	499	774
Kaukauna 1st Lock	443	694	338	575	475	781	483	689
Kaukauna 2nd	441	691	338	576	475	781	483	789
Kaukauna 3rd	449	717	359	614	463	766	478	786
Kaukauna 4th	442	708	378	656	458	757	491	782
Kaukauna 5th	442	708	400	688	458	757	491	782
Rapide Croche	514	708	464	691	539	819	561	830
Little Kaukauna	1,045	1,531	1,002	1,369	1,080	1,463	1,133	1,708
DePere	1,590	2,396	1,645	2,489	1,773	2,623	1,878	3,008
Total	11,265	16,975	11,019	17,172	12,550	19,570	12,834	20,393
(non-recreational) 1/	(574)	(786)	(498)	(705)	(658)	(1,003)	(656)	(993)
System Transit (maximum) 2/		306		288		388		387

1/ Includes Corps of Engineers and Coast Guard vessels and equipment and some commercial fishing vessels.
2/ Lowest common number of craft locking through all locks x .5 (adjustment for round trip).

Source: Corps of Engineers.

2.151
<u>Fishing</u> - As with boating, fishing has achieved greater popularity as a form of recreation. The number of licensed fishermen in Wisconsin grew more than 20 percent between 1968-1974. Table 2.25 shows 1974 fishing license data for the 8-county area, with a substantial number being non-resident licenses.

2.152
Water quality problems are a serious deterrent to fishing in a large portion of the project area. The rivers and the lakes suffer from various types and degrees of pollution, and the effects of the contaminants are almost always detrimental to sport fish populations. Some recovery of the usefulness of these waters as a recreation resource is being made because of new sewage and industrial treatment facilities, and even greater potential exists for increasing fishing opportunities if water quality and utilization of the bodies of water, which presently exist in the region but are lacking one or more components necessary to satisfy fishing demands, are improved.

2.153
The problem of poor water quality is especially apparent in the Lower Fox River. At present, the water quality of the Fox River (especially dissolved oxygen) is so poor that a sport fishery of any importance cannot be established. The Lower Fox River, the largest stream in the Fox valley corridor, contains a very marginal fishery consisting primarily of rough fish, walleyes, bass, northern pike, and panfish. In many stream reaches the pollution load of the Fox is so great that there is not sufficient dissolved oxygen to support a fishery much of the year.[97]

Table 2.25. Fishing License Data, 1974

County	Resident licenses[a]	Non-resident licenses
Brown	27,312	679
Calumet	5,987	204
Fond du Lac	19,619	2,920
Green Lake	7,585	632
Outagamie	23,759	569
Waupaca	15,860	18,200
Waushara	7,535	2,394
Winnebago	30,035	8,990
Total	137,692	34,588
Percent of State	14.5	9.8

[a]*Effective number of fishing licenses.*

Source: Wisconsin Department of Natural Resources, 1974.

Summerkills of fish are common. These kills can be [illegible] to oxygen depletion due to algae die-offs and to industrial pollution. During the spring in several recent years, local residents were encouraged to see white bass and perch in the Fox River as far upstream as the Rapide Croche dam. These fish could survive as long as surface runoff was providing a large volume of water and the dam was aerating the water spilling over it, and good fishing was supplied to area youngsters. However, as surface waters reached normal levels, the dissolved oxygen level downstream reached zero. The result was a summerkill among the fish trying to return to Green Bay; only those fish remaining near the dam survived. Erosion of clayey upland soils has also created very turbid conditions in the river. Factors such as erosion of shorelands, siltation of pools, excess rates of eutrophication, and destruction of wetlands have contributed to habitat decline.

2.154
Without question, Lake Winnebago is the most popular and heavily fished area in the central project region. The water in Lake Winnebago is fertile and very productive and as such the lake supports a very diverse fishery. Walleye, sauger, perch, white bass, and northern pike provide excellent fishing opportunities. Ice fishing for walleye and sauger is very popular during the winter months, as is the spearing of the large lake sturgeon during the open season.

2.155
The Wolf River supports the region's most important fishery and supports the most fishing activity of any water in the region. The Wolf and adjacent wetlands provide excellent spawning habitat and feeding areas for many species of warm water game fish. The spring spawning migrations of walleye and white bass annually attract thousands of anglers. The walleye run occurs shortly after the ice leaves and therefore the walleye run offers fishermen the first major open water fishing in Wisconsin.

2.156
Many other lakes and streams of the project area provide a variety of fish and fishing. The larger lakes contain the best fisheries and the best public access facilities support the heaviest lake oriented fishing pressure. Many smaller lakes in the project region have frequent or annual winterkills of fish due to their shallow, fertile nature. The other lakes are classified primarily as "bass-panfish" lakes, and due to this same fertility produce large poundages of fish. Unfortunately, the poundage in some is made up of many small, slow-growing panfish, rather than desirable sized fish. Smaller streams are generally lightly fished, and offer only minimal fisheries. Lack of sufficient base flow in streams, along with erosion, siltation, excess fertility, and high turbidity have combined to make many waters uninhabitable for most game fish. Stream erosion has destroyed some spawning habitat for game fish. Cover, other than aquatic vegetation, is scarce on most streams. Wetland drainage is another problem which has destroyed fish spawning areas and wildlife areas in the project region. This problem affects many lakes and streams including Lake Winnebago and other lakes along the Wolf River system in Winnebago and Waupaca Counties. Walleyes from Lake Winnebago spawn in

the marshes adjacent to the Wolf and its major tributaries. The more these marshes are drained or otherwise altered the fewer opportunities walleyes will have to spawn; this could eventually result in reduction of the walleye population in the entire Winnebago-Wolf system.

2.157
Swimming - In terms of recreation occasions, swimming is the most popular recreational activity in the area. However, swimming opportunity deficiencies have occurred due to the medium to poor quality of the natural beaches and their adjacent waters. The major problem is the aesthetic degradation of the water primarily by dense algal growths, odors from anaerobic situations and general debris. Pollution by toxic materials has also contributed. Swimming pool construction has circumvented the dependency on the natural resource base to a certain extent, and swimming is largely confined to pools in the urban area. A substantial percent of swimming participation occurs outside the region.

2.158
Hunting - Hunting is a popular project area recreational activity. From 1968 to 1974, the number of hunting licenses issued statewide grew from 767,198 to 1,405,254, or 83 percent. Only 1974 data is available for the 8-county study area. However, because of the attractiveness of the Lake Winnebago and Waupaca areas, among others for duck and deer hunting, respectively, it is felt that the region's growth in licensing reflects that of the state. Selected data are presented in Table 2.26.

Table 2.26. Hunting License Data, 1974

County	Resident small game	Resident deer	Resident archers	Resident junior archers	Voluntary sportsmen
Brown	8,546	10,717	2,925	968	7,322
Calumet	972	1,459	369	196	1,380
Fond du Lac	5,225	5,500	2,161	739	5,466
Green Lake	1,370	1,941	839	370	2,211
Outagamie	6,289	8,278	2,518	1,166	6,512
Waupaca	2,437	5,740	2,430	1,212	4,203
Waushara	1,146	2,369	877	354	1,855
Winnebago	6,600	8,475	3,514	1,182	7,461
Total	32,585	44,479	15,633	6,187	36,410
Percent of state	6.7	8.1	18.6	21.2	14.0

Source: Wisconsin Department of Natural Resources, 1974.

2.159
The Wisconsin Department of Natural Resources administers the bulk of the land listed as open for hunting. As in most regions of the state, however, private property owners accommodate a major portion of hunting demand. Posting of private land against trespass limits hunting opportunities in some parts of the project area. Additional hunting opportunities on a pay-as-you-go basis are provided by private shooting preserves. Game species common to the project area include muskrats, mink, and deer. Beaver and otter are present but much less common. Upland species include deer, grouse, Hungarian partridge, squirrels, rabbits, pheasants, fox, and racoon. Waterfowl are among the most important common and important of wildlife users of the project's water surface.

2.160
Several large marshes and the project region's shallow lakes are major sources of waterfowl habitat. Concentrations of 50,000-100,000 waterfowl, mainly diving duck species including scaup and canvasback, gather on Lake Winnebago each autumn. Lesser numbers of puddle ducks may also be found here but are more common on the southern end in the Supple Marsh area and along the Wolf and Embarrass Rivers. The west shore of Lake Winnebago and its associated islands in Fond du Lac County offer some of the finest duck hunting opportunities in the entire state, and many birds are harvested annually. Poygan Marsh provides public hunting grounds for waterfowl and small game and the wetlands along the Wolf often provide excellent duck hunting.

2.161
Hunting opportunity (in both quantity and quality) have decreased during the past decade in the project region. Waterfowl are not nearly as abundant as they were a few years ago. This can be explained in part by the general decrease in waterfowl populations in North America. Other factors such as destruction of marshes, destruction of aquatic vegetation such as wild rice, and declines in water quality further limit waterfowl and other wilflife populations. Agricultural practices such as intensive cultivation, stream bank pasturing, and roadside brush cutting are directly responsible for much habitat destruction and subsequent wildlife declines. More subtle factors such as the spread of carp, and the increase in boat traffic may also have an effect. Quality of the hunting experience has also declined as rapidly as the quality of available resources. An increasing population, intensification of land use, and loss of wildlife habitat suggest a decline of hunting as a major recreation activity. However, recent attempts at habitat improvement, better water quality, and reducing cultivation of marginal crop lands could spur an increase in game animal populations.

2.162
Camping and Picnicking - Private enterprise provides the bulk of the campground capacity in the region. Facility quality is variable but congestion is not common. Crowding does occur in popular areas. Out-of-state use greatly exceeds local participation. Establishing primitive canoe campsites along the Fox and Wolf Rivers would contribute to the elimination of primitive campsite deficiencies.

2.163
Local units of government are followed by private enterprise as the major providers of picnicking facilities in the project region. Parks offering picnic facilities generally maintain good levels of site quality.

2.164
Table 2.27 presents the kinds and numbers of recreation facilities recognized by the Department of Transportation for seven counties (excluding Green Lake) in the project area. Camping and picnicking are considered together since both usually require public recreational facilities. A total of 110 separate recreational facilities are recorded with about one-half of these sites having established picnicking and camping areas. Additional sites without facilities are maintained as public hunting and fishing grounds. The counties of Brown, Fond du Lac, and Waupaca have the most recreational facilities in the eight county area. A census of people using these facilities is available only for the State parks and forests. A total of 1,322,259 visitors and 189,767 campers were recorded at High Cliff, Hartman Creek, and Kettle Moraine-Northern Unit (NU) State Parks in 1974 (Table 2.28). From 1973 to 1974 the number of visitors decreased by 1.8 percent, whereas the number of campers increased by 12.2 percent.

2.165
Sightseeing - Some of the more scenic recreation resources in the project area and vicinity include the Kettle Moraine and Lake Winnebago areas, the Fox and Wolf Rivers and their tributaries and impoundments, and scattered small undeveloped lakes. Continued land use changes in the region may reduce its desirability for sightseeing purposes and result in reduced participation or a shift of demand to other regions. More specifically, intensive agricultural practices, shoreline development and wetland drainage and filling is reducing opportunities for enjoyable sightseeing. Continuation of this type of development will result in reduced sightseeing participation in the region.

2.166
Winter Sports - Snowmobiling and ice fishing are popular winter sports in the study area. Snowmobile records are available for Wisconsin counties for 15 March 1975, from the Wisconsin Department of Natural Resources. The eight counties in the project area and their numbers of snowmobiles are listed below. When compared with other counties in the State, some of the project study areas are among the highest in registered snowmobiles. The list summarizes study area snowmobile registration. Ice fishing on Lake Winnebago, especially sturgeon spearing, is also a major form of winter recreation in the project area.

County	Snowmobiles	County	Snowmobiles
Brown	10,541	Outagamie	8,042
Calumet	2,869	Waupaca	4,509
Fond du Lac	6.992	Waushara	2,154
Green Lake	2,170	Winnebago	7,798
		Total	45,075

Source: Wisconsin Dept. of Natural Resources, 1975.

Table 2.27. 1975 Recreational Facilities Inventory

County	Public camp and picnic grounds: Without camp-sites	Public camp and picnic grounds: With camp-sites	State Parks: Without camp-sites	State Parks: With facil-ities	County Parks: Without facil-ities	County Parks: With facil-ities	Wayside: Without facilities	Public hunting or fishing grounds	National and State Forests	Total
Brown				2		4	2	2		10
Calumet		1		1		2	2	5		12
Fond du Lac		2		3		4	1	9	Kettle Moraine State Forest & Horicon Nat. Wildlife Refuge (part in other county)	19
Outagamie						2	1	6		9
Waupaca		1		1	1	1	3	15		22
Washara						1	1	13		15
Winnebago					3	2	1	8		14
Totals		4		7	4	16	11	58	2	102

Source: Dept. of Transportation, Division of Highways, Madison, January 1975.

Table 2.28. State Park and Forest Visitation 1973-1974

Name	1972 Visitors	1972 Campers	1974 Visitors	1974 Campers
High Cliff	526,108	22,772	434,650	23,248
Hartman Creek	140,196	26,229	99,265	37,162
Kettle Moraine 1/	679,546	120,108	788,344	129,357
Total	1,345,850	169,109	1,322,259	189,767

1/ Northern limit.

Source: Wisconsin Department of Natural Resources, 1974.

2.167
Growing Demand for Water-Based Recreation - The region's water resources provide the basis for a wide variety of recreational activities, particularly fishing, hunting, boating and swimming. These activities are making increasing claims to the use of the region's lakes, streams and wetlands. Not only have there been numerous conflicts between recreation and other potential water uses, but there have also been conflicts between various types of recreational activities, such as fishing and power boating. The need for a rational basis for allocating water resources among competing users has become increasingly urgent.

2.168
The number of sport fishermen has grown steadily over the past few decades. Fishermen and hunters, attracted by the region's trout, bass, and pike, and various wildlife species, come from far and wide to fish in the region. Fear that increasing industrialization and agricultural development will harm fish and wildlife habitat has encouraged fishermen, hunters, and conservationists to petition for preservation of various parts of the region for recreational purposes. Programs of purchasing wetland area are one result. Regulations on water use are another.

2.169
Boating, and particularly power boating, has increased rapidly in the region in recent years. Not only do local residents own a large number of boats, but the region has become an increasing attraction for boatsmen from the surrounding area. Demand for pleasure boating will continue to increase at a rapid rate in the region, bringing increased demands for mooring facilities and associated services. It will also give rise to certain conflicts in water use, both between different types of recreational activities and between recreation and other water uses.

2.170
Protection of Project Water Recreational Resource - Although the project region possesses many valuable recreation resources, it has several serious problems related to the quality of its surface waters and the

current patterns of land use and development. Silt, agricultural chemicals, domestic sanitary wastes, and industrial byproducts are the major deleterious substances contaminating the region's surface waters.

2.171
Control of municipal and industrial effluents is being effected, but siltation, agricultural chemicals and fertilizers, and individual sanitary systems located on lake and river shorelines are not as readily dealt with. If good water quality is to be maintained and poor water quality improved, attention must be focused on these more dispersed sources of pollution.

2.172
The primary water recreational resources include the Fox and Wolf Rivers and Lake Winnebago. The quality of these resources varies but in general, if their potentials are to be realized improvements will be needed.

HISTORICAL AND ARCHEOLOGICAL FEATURES

Historical Development of the Region

2.173
The Fox and Wolf Rivers have had many historic associations during the last three centuries, some of these having a rather close connection to the early settlement and economic development of the State of Wisconsin.

2.174
Indian Tribes and Colonial Trade - The Winnebago and Menominee tribes were apparently the major Indian nations inhabiting the region prior to the settlement of the white man. The Winnebagos met the French explorer Jean Nicolet when he landed near Green Bay in 1634. Nicolet was the first white man to view the Lower Fox Valley and the "Lion of the Fox", the Indian name for the roaring rapids of the river. Subsequently, explorers, traders, and missionaries found the river to be a natural trade route between the Great Lakes and the Mississippi River. Fur was the main attraction to the French traders.

2.175
Domination in this part of the state was assumed by the British after the French and Indian War in 1763. Fur trade continued to be the prime attraction. In 1815, the English relinquished control in the area. In 1854, after a series of concessions to the white settlers, and during which time their tribal holdings were greatly diminished, the United States government ceded to the Menominee tribe, in trust, a reservation in parts of Shawano and Oconto counties (now Menominee County).

2.176
Settlement - The first permanent settler was Augustin de Langlade, who with his family of eight, moved to the area between 1744 and 1746. Forty years later the Bay colony settled by Langlade had a total population of 56. This grew to 252 by 1812 and to 500 by 1824 (not including the 600 troops stationed at Fort Howard).

2.177
In 1816, the first water powered grist mill in Wisconsin was built by Augustin Grignon in the area now called Kaukauna. Kimberly, first called Smithfield, was settled in 1822 by Christian Indians from New York. The Little Chute area was settled by the Rev. T. J. Vanden Brock in 1835. Amos Lawrence established an institute of higher learning at Appleton in 1847; the community was named after Lawrence's father-in-law Samuel Appleton. Early development of the Neenah-Menasha area came in the late 1840's. In 1873 the first paper mill in the area was established at Kaukauna.

2.178
Surface water resources have always played an important role in the history and development of the region. The first explorers and settlers were brought to the valley over waterways. These same watercourses served as highways over which first furs, then agricultural products and later industrial products moved to markets in the east. Appleton, Kimberly, Little Chute, Combined Locks, and Kaukauna developed and grew around sites suitable for waterpower development. Waterpower and easy access to markets and raw materials attracted the paper industry.

2.179
Fond du Lac, meaning Bottom of Lake, derived its name from a Menomonie Indian Village named Wanikamiu. Although explorers came to the area earlier, records indicate that the first home was built in 1836. In 1847, the area which is now known as Fond du Lac became incorporated as a village. The following years brought the railroads which with the lumber industry was responsible for the rapid growth of the area.

2.180
The City of Oshkosh, Wisconsin, was settled in about 1827 as a trading post along the route between the Great Lakes and the Mississippi River. In 1840, the city received its name and in 1853, became incorporated as a city. Because of its ideal location, it continued to grow, with the Fox River continuing to serve as a principal source of transportation for the subsequent logging era and agricultural developments.

2.181
Transportation - The unique river system formed by the Fox and Wisconsin rivers made it possible to travel across the state by water from the Green Bay to the Mississippi River with only a minor interruption at Portage. This was a favorite route of early explorers and pioneers. In 1855, a series of locks was installed on the Fox River between Appleton and Green Bay which made the river system navigable for commerce. The two rivers provided a major transportation route during the middle of the nineteenth century, and before the prominence of railroads. The river route contributed significantly to the early development of southern counties of the region--mainly Winnebago and Outagamie counties.

2.182
Wisconsin first received rail service in 1851 (to the Milwaukee-Waukesha area). By 1860, service had been extended as far north as Oshkosh. In

1861, it was extended to Appleton. During the next two decades rail service reached most of the northern and western sectors of the region. The Chicago and Northwestern Railway Company reached New London in 1876. It then extended service northwest to Eland and then north by way of Antigo, Monico, and Eagle River, reaching the northern Michigan state line in 1883. The Wisconsin Central and Soo Line Railroad extended service from Menasha to Stevens Point and on to Ashland between 1871-77. In 1918, the company completed a line from Argonne in Forest County to Appleton by way of Shawano for the purpose of bringing wood to the pulp and paper mills of the southern cities. The Green Bay and Western, another major firm operating in the region, extended service from Green Bay to the Mississippi River between 1866-1873.

2.183
Agricultural Development - Between the period 1835-1850, most of the land in southern Wisconsin was made into farms; although it generally took several years before all the land of a farm was improved. In 1850, the northern boundary of this farm belt was fixed quite firmly along the Fox-Wisconsin water route. The raising of wheat was the basis of the agricultural economy. By 1860, the farm line extended north and west to include most of Outagamie, Waupaca, and Waushara counties. As rail service was extended to the northern counties in the 1870's, agriculture was brought into these areas. Agricultural development was stimulated by existing lumber and sawmill towns. Towns and lumber camps provided a ready market for farm crops and during the winter months the lumber camps served as a source of employment for the farmers. It was a mutually advantageous situation. Excess crops were shipped south to market via the railroads. Wheat remained the major crop for several decades, but gradually gave way to dairying and animal feed crops during the latter part of the nineteenth century.

2.184
Lumber Era - In the early 1840's, a new era of economic activity began in the Wolf River Basin with the advent of pine lumbering. For several decades the only merchantable timber in Wisconsin was pine. White pine timber was considered the choice of the pines and the Wolf River Basin area contained some of the finest white pine forests in the state.

2.185
Although logs were cut in the Basin in 1835 for the erection of government buildings at Neenah, the first commercial lumbering operations did not begin until 1842. The lumbering operations tended to fix the location of several cities and villages in the region. Shawano and Winneconne became the chief sawmill towns on the Wolf River. It was at Oshkosh and Fond du Lac, however, where most of the logs were made into lumber. The slow current that characterizes the Wolf from the City of Shawano south made the river an excellent logging stream. Lake Poygan provided a good reservoir for the temporary storing of logs. Sawmill operations began in Oshkosh in 1847 and Oshkosh was later to become known as "Sawdust City". The Cities of Neenah, Menasha, and Appleton also received logs from the Wolf Basin and each had several sawmills; however, they never approached the operations in Oshkosh or Fond du Lac.

2.186
In 1854, forty million feet of lumber was manufactured out of logs from the Wolf River district. The production peak was reached twenty years later when the eighty lumber camps in the woods of the upper Wolf Basin cut a total of 205,000,000 feet. Soon after reaching this peak, production began to steadily decline, and by 1890, the pine was all but depleted.

2.187
Industrial Growth - The region's industrial developments tended to concentrate in the Oshkosh to Kaukauna corridor along the shores of the Fox River. The abrupt descent of the Lower Fox in this area made its potential very attractive to industries dependent on water power.

2.188
The first major industrial activity started in the 1840's and focused on sawmill operations from lumber floated down the Wolf-Fox waterways. The growth of agriculture in the hinterlands during the 1850's provided the basis for another important operation--the development of flour milling industries to process the area's wheat crop.

2.189
The industry that was to become the most important economic activity in the Fox City's area, paper manufacturing, appeared as early as 1853 in the Appleton area. However, most of the major paper firms did not get a firm start until the 1870's and early 1880's. Today the paper and allied products industry is the largest manufacturing employment group in the region.

Historical Places, Archeological Sites and Natural Landmarks

2.190
The State Historical Society and the National Park Service have been contacted and the National Register of Historic Places consulted in regard to historical or archeological resources which might be located in the project area. No known historical or archeological sites will be affected by the proposed action. Table 2.29 lists the historic places and natural landmarks in the eight counties of the project study area. Only one listed natural landmark exists in the area, the Spruce Lake Bog-Kettle Moraine State Forest.[48] The remaining 15 of the 16 items shown are historic places.[49] No other registered historic places or natural landmarks are known to exist in the project study area. Figure 2.13 shows the location of each of the items identified in Table 2.29. All of the historic places are buildings with the exception of one which is a cemetery. All listed historic places are remnants of the historic settlement period. The archeological sites (pre-historic settlement period) are not publicly listed to prevent their disruption or destruction by untrained persons. This entire area, however, has been occupied since prehistory by aboriginals and is very rich in sites having archeological significance. Some of these sites are known and are listed in the State of Wisconsin, Archeological Office, and with the State Archeological Society. Other undiscovered sites probably exist.

Table 2.29. Federal Registry of Natural Landmarks and Historic Places in the Project Area[a]

No.	Natural Landmark (NL) or Historic Place (HP)	County	Specific Location
1.	Spruce Lake Bog-Kettle Moraine State Forest (NL)	Fond du Lac	Two miles northwest of the Village of Dundee
2.	Octagon House (HP)	Fond du Lac	276 Linden Street, Fond du Lac
3.	Little White Schoolhouse (HP)	Fond du Lac	Southeast corner of Blackburn and Blossom Streets, Ripon
4.	St. Peter's Episcopal Church (HP)	Fond du Lac	217 Houston Street, Ripon
5.	Woodruff, Jacob House (HP)	Fond du Lac	610 Liberty Street, Ripon
6.	Recording Angel, Forest Mound Cemetery (HP)	Fond du Lac	North Madison Street, Waupun
7.	Hearthstone (HP)	Outagamie	625 W. Prospect Ave., Appleton
8.	Main Hall, Lawrence Univ. (HP)	Outagamie	400-500 E. College Ave., Appleton
9.	Volksfreund Building (HP)	Outagamie	200 E. College Ave., Appleton
10.	Grignon, Charles A. House (HP)	Outagamie	Augustine Street, Kaukauna
11.	Babcock, Havilah House (HP)	Winnebago	537 E. Wisconsin Ave., Neenah
12.	Grand Loggery, Doty Park (HP)	Winnebago	Lincoln Street, Neenah
13.	First Presbyterian Church (HP)	Winnebago	110 Church Ave., Oshkosh
14.	Oshkosh Grand Opera House (HP)	Winnebago	100 High Ave., Oshkosh
15.	Algoma Boulevard Methodist Church (HP)	Winnebago	1174 Alhoma Boulevard, Oshkosh
16.	Trinity Episcopal Church (HP)	Winnebago	203 Algoma Boulevard, Oshkosh

[a]*Department of the Interior, National Park Service No. 1 (National Registry of Natural Landmarks, Part 1, Sept. 5, 1975, Vol. 38 No. 208: 20505); Nos. 2-16 (National Register of Historic Places, Part 2, Feb. 4, 1974, Vol. 40 No. 24:5339-5341).*

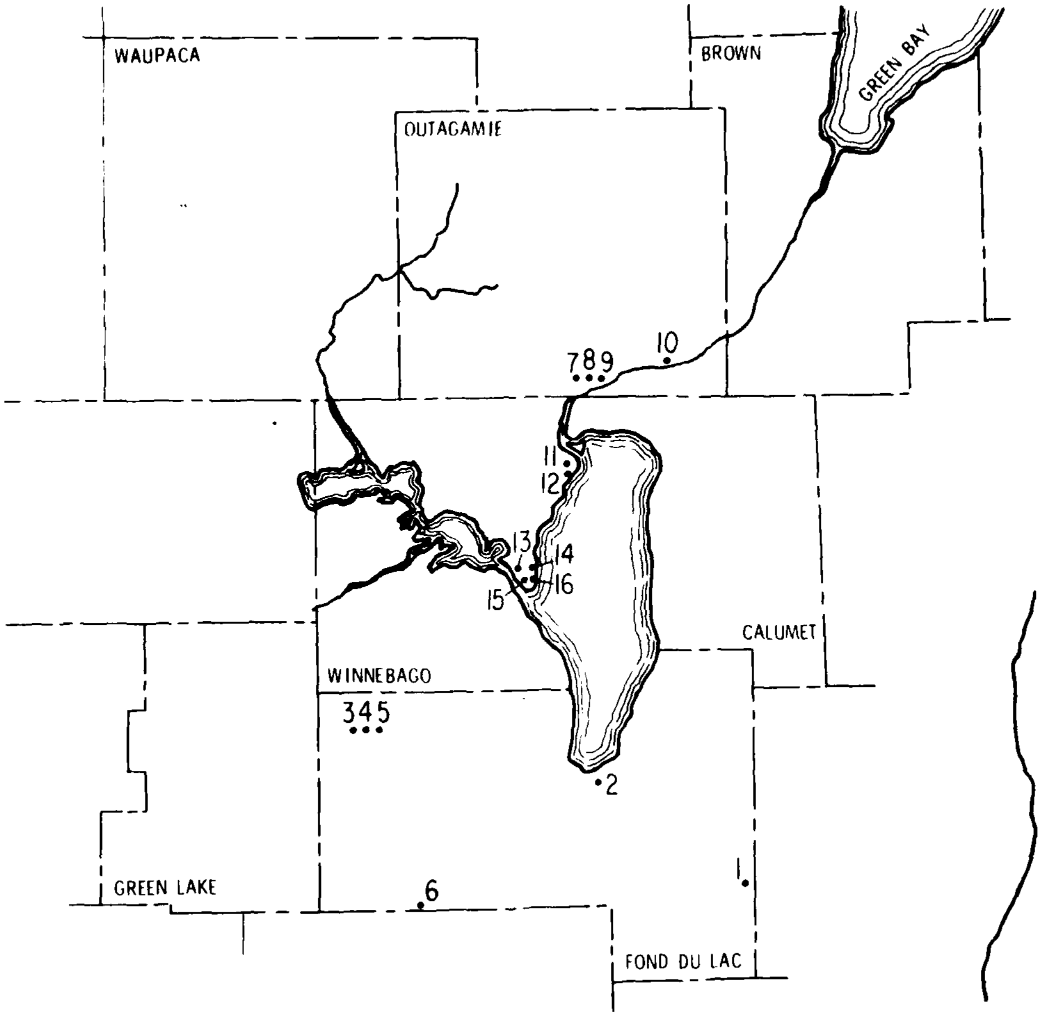

Fig. 2.13. Location of National Registry of Natural Landmarks and Historic Places (see Table 2.26).

2.191
At the request of the State Historical Preservation Officer, a professional archeological assessment survey of proposed dredged material disposal sites was undertaken in order to locate and evaluate cultural resource sites for possible inclusion in the National Register of Historic Places. The Summary and Recommendations section of the survey report states that no adverse effects upon cultural resources should result from proposed dredged material disposal terrain modifications. Figure 2.14 is a reproduction of a 19 November 1976 letter from the State Historic Preservation Officer concurring with this determination. It should be pointed out that the specific references in this letter to the nature and location of an archeological site in the vicinity of a disposal site no longer proposed for use have been withheld from publication. This was done in order to protect the site from possible vandalism.

HYDROLOGIC AND HYDRAULIC ELEMENTS

2.192
The hydrology of the entire Wolf-Fox River Basin (of which the project study area is a large part) reflects the geology, topography, size and climate of the basin complicated by man-made changes, such as dams and land use. Where permeable, thick, and extensive near-surface aquifers underlie the basin, base runoff to streams is large and the stream has a consistently high sustained flow. Floods from overland runoff are reduced because water from precipitation and snow-melt easily enters groundwater storage. Conversely, where aquifers are relatively impermeable, thin, or areally small, base runoff is low and streamflow is highly variable and diminishes greatly during the late summer. Such streams are generally subject to flash floods since most of the water from large rainstorms or sudden spring thaws flows overland, and only a small part enters groundwater storage. Thus, the water yield per square mile in the poorly permeable glacial-lake and ground moraine areas in the central, eastern, and southern parts of the basin (study area) is lower than that of the permeable glacial outwash areas in the western and northern parts. This can be demonstrated through use of flow-duration curves which reflect natural streamflow. The shape of a flow-duration curve can also reflect the geohydrology of the drainage basin. Curves with a steep slope denote highly variable streams whose flows are largely from direct runoff, whereas curves with flat slopes indicate the presence of surface or groundwater basin storage, which tends to equalize flow. Figure 2.15 exhibits flow duration curves for several streams in the project vicinity.

2.193
The major streams (point source inflow) contributing directly to the study area, their average, maximum and minimum flows are tabulated on the next page.

2.194
Flood flow and low flow recurrence curves of major streams in the vicinity of the study area are shown in Figures 2.16 and 2.17. Additional stream discharge data is contained in Appendix F.

THE STATE HISTORICAL
SOCIETY OF WISCONSIN

November 19, 1976

Mr. Raymond P. Essell
Chicago District, Corps of Engineers
219 South Dearborn Street
Chicago, Illinois 60604

Dear Mr. Essell:

Our staff archeologists have reviewed the report entitled "Archaeological Survey for Fox River Navigation Project Disposal Sites" prepared by Dr. David F. Overstreet of the Great Lakes Archaeological Research Center, Inc. under Contract No. DACW23-76-C-0082 with your agency.

The procedures used during this survey were adequate to support the conclusion that no archeological sites are present in the following proposed dredge disposal sites:

Surface conditions at the dredge disposal site on the Wells Coal and Dock Company property did not permit a definitive statement concerning the presence of archeological resources in this area. It appears that this proposed disposal site has been severely disturbed by twentieth century construction. Any prehistoric or historic archeological sites that may have existed in this area were probably very thoroughly obliterated by this construction and we feel that it is unlikely that the proposal to dispose of dredged material on this site would have further adverse effects on any potential resources in this location.

The survey of located one multi-component (Archaic-Woodland) archeological site on the property. At the recommendation of Dr. Overstreet a verbal agreement was made with you that no dredge spoils would be deposited on this site which is located east of

With the stipulation that dredge spoils from are not deposited east of on the , we feel that this project will have no effect on prehistoric or historic archeological resources.

Sincerely,

Richard A. Erney
State Historic Preservation Officer

RAE:rdd

cc: Dr. David Overstreet

Fig. 2.14. Letter from the State Historical Society of Wisconsin.

Area Stream Discharges (point source inflows, cfs)

	Avg.	Max.	Min.
Wolf River (New London)[a]	1,729	15,500	150
Little Wolf R. (Royalton)[b]	423	6,950	38
Waupaca R. (Waupaca)[b]	238	2,520	50
Fox R. (Berlin)[a]	1,089	6,900	248
Fond du Lac R. (Fond du Lac)	64	-	-

[a] *Water Resources Data for Wisconsin 1973, USDOI, USGS and State of Wisc.*

[b] *Groundwater resources of Waupaca County USGS WSP ......*

2.195
Fox River and Lake Winnebago - The flood plain of the Fox River is highly developed with industry and commercial establishments in urban areas and with residential establishments in the suburban areas. The flood plain of the Fox River from the Brown County-Outagamie County line upstream to the Kaukauna city limits is narrow and there is no significant development in this area. A few cottages have sprung up on the narrow benches next to the river but most of the more recent development has been on top of the bluffs, well above potential flood hazard areas. Within the corporate limits of Kaukauna there has been considerable industrial, commercial and residential development of the flood plain. New development and redevelopment is currently underway in this area. In Little Chute and Combined Locks, the narrow flood plains are almost entirely utilized by industrial development and municipal utilities. Flood plain areas in the City of Kimberly are utilized by industry and recreational development. Recreational facilities such as ball parks are a compatible usage of flood plain areas. Within the corporate limits of Appleton, the flood plain lands are nearly completely developed. Industry is the major usage with a smaller area being utilized for a waste treatment plant. Almost all of the residential development has been on top of the bluffs, well above any potential flood hazard. Around Little Lake Butte des Morts there is considerable residential development. Some of the houses are constructed close to the lakeshore and are subject to damage during times of high water. Residences on Stroebe Island will be isolated during higher frequency floods due to flooding of Stroebe Road. The Neenah-Menasha wastewater treatment plant is located on the lake and would be subject to flooding from floods greater than the Intermediate Regional. In Neenah and Menasha, industrial development along the Fox River is very intense and in some areas buildings are constructed on piling over the stream channel. In other areas, the only floodway

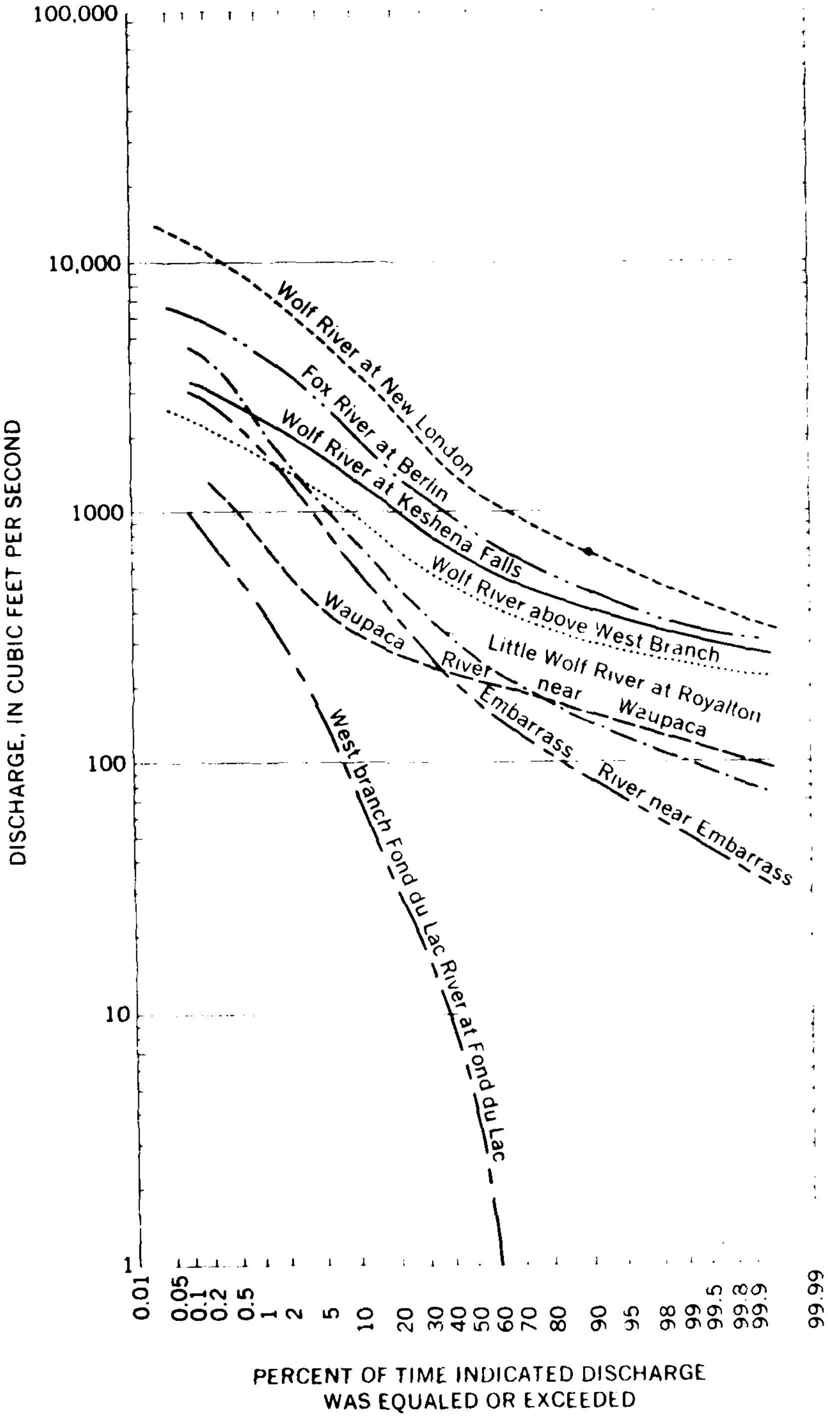

Fig. 2.15. **Flow Duration of Major Streams. From P. G. Olcott, "Hydrologic Atlas," 1968.**

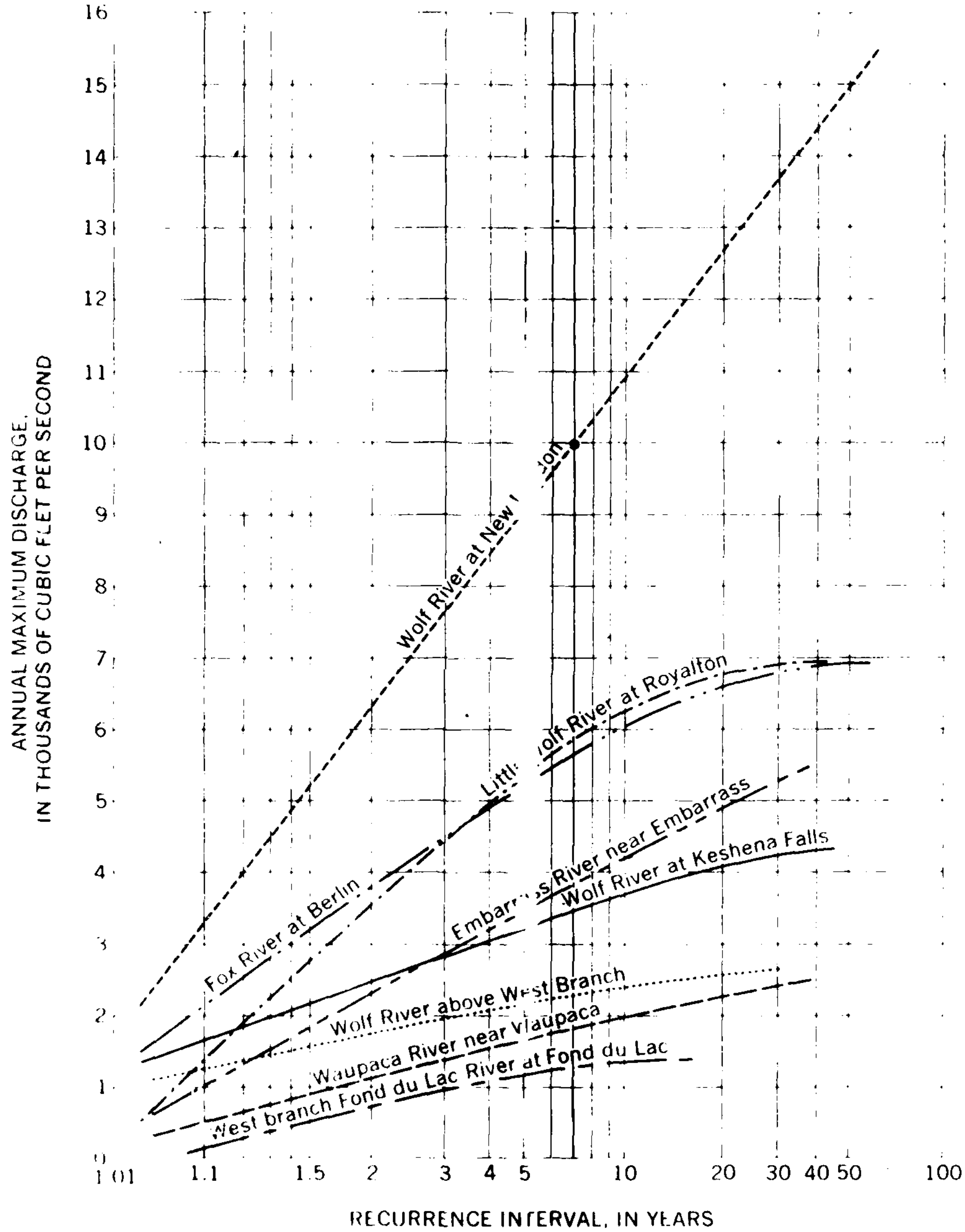

Fig. 2.16. Floodflow Recurrence of Major Streams. From P. G. Olcott, "Hydrologic Atlas," 1968.

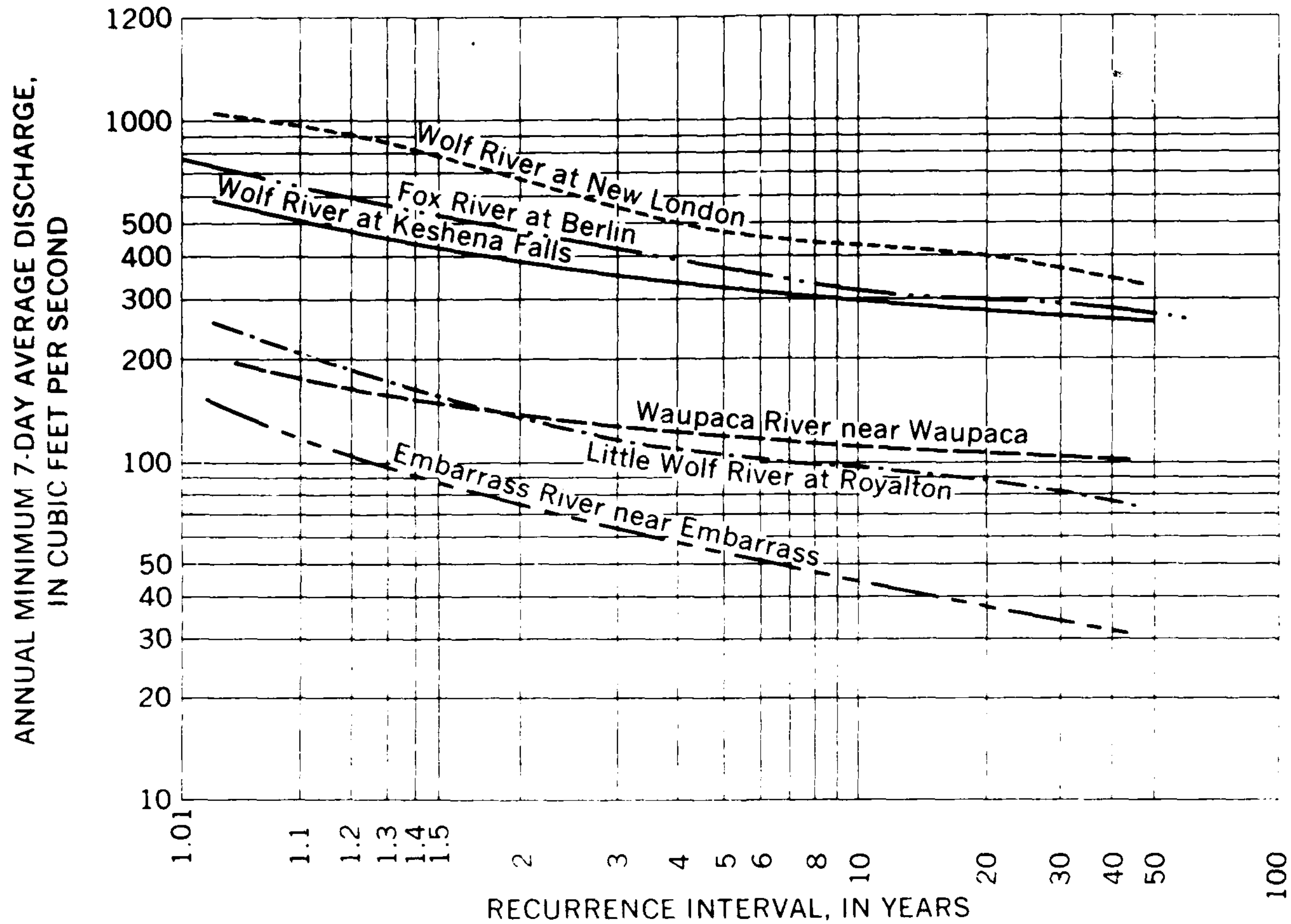

Fig. 2.17. Low-Flow Recurrence of Major Streams. From P. G. Olcott, "Hydrologic Atlas," 1968.

remaining is that between buildings which are constructed right on the river bank. Along the shore of Lake Winnebago, the development has been almost entirely residential with small areas devoted to parks. The 1970 population of the area along the Lower Fox River was approximately 147,000 people. The projected 1990 population for this area, based on the East Central Wisconsin Regional Planning Commission Comprehensive plan, is approximately 157,000 people.

2.196
Like the cities of Neenah and Menasha, the cities of Oshkosh and Fond du Lac are located on relatively low land around the lakeshore. The flood plain within the City of Oshkosh includes residential, commercial, industrial and recreational developments. Flood plain developments along Lake Winnebago north of Oshkosh are institutional and residential. Residential developments along the Lake Winnebago flood plain are extensive in the immediate Oshkosh area and less extensive farther to the north. Railroads, highways, streets, utility lines, industries, and the Oshkosh sewage treatment plant and water filtration plant are subject to flooding. The flood plain of Oshkosh is almost fully developed. The present population of the city, as determined in the 1970 census, is 53,104. Its population is projected to be 61,087 by 1980. The flood plain of the Fond du Lac River is highly industrialized, particularly near the junction of the East and West Branches. Parks and open areas are predominant north of Scott Street near Lake Winnebago. Residential developments are predominant south of the industrial area. The Fond du Lac River flood plain within the City of Fond du Lac includes residential, commercial and industrial developments. Railroads, highways, streets, utility lines, production facilities, and lift stations are all located within the areas that would be subject to flooding. Due to the extremely flat topography the City of Fond du Lac has constructed 19 lift stations for removal of runoff water throughout the city. The 1970 population of the City was 35,515, which is approximately an 8.5 percent increase over 1960. The projected population for the City based on an average increase is approximately 40,000 people by 1990.

2.197
Floods have occurred in the study reaches of the Fox River and along the Lake Winnebago shore during all seasons of the year with the more extensive floods in the spring. Although the rate of stream rise from general rains over the basin is moderated by Lake Winnebago, intense rainfall downstream from Lake Winnebago may result in a fast rate of rise, or flash flood condition there. Flood stages in Lake Winnebago rise slowly with extremely low velocities occurring in the general direction of flow from Oshkosh to Neenah.

2.198
The floods can occur entirely from rainfall, from snowmelt, or from a combination of both. Flooding along the Lake Winnebago shoreline can also occur with any of these situations and, in addition, from extensive wind action sweeping onto the shore from easterly or southerly directions. This wind action causes the water surface to tilt upward (wind setup) and also creates wave action (wave runup) which can cause flooding and severe erosion. Figure 2.18 illustrates this condition.

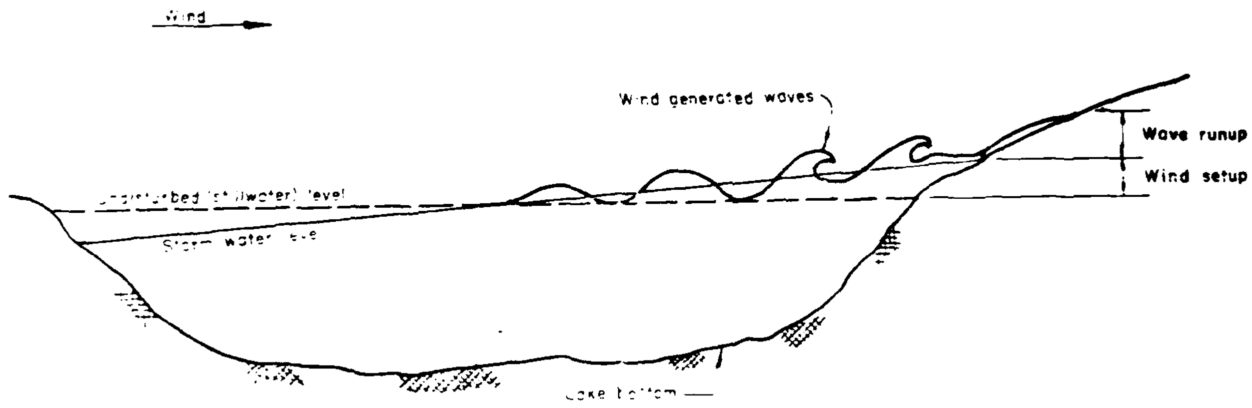

Fig. 2.18. Wind Effect on Lake Winnebago Water Levels

2.199
Flooding is not a serious problem on the Lower Fox, although high water sometimes disrupts industries located in low-lying portions of the flood plain. Also, open spaces in the flood plains which may come under for development are limited.

2.200
The temporary storage of floodwaters in Lake Winnebago reduces the peak flows on the Lower Fox River; however, the duration of high water can extend over several weeks as it did during the spring of 1973. Strong winds blowing onto the shore will produce high water due to wind setup and also wave runup. These have damaging effects on structures and also cause considerable erosion of the shorelands. During the "breakup" of the ice, strong winds will blow ice onto the shorelands and cause damages.

2.201
Damaging floods are reported to have occurred in the Fox Valley area as early as 1881. More recent floods causing significant damages in the study reach occurred in 1922, 1929, 1943, 1946, 1951, 1952, 1960, and 1973. Of these, the 1922 flood caused the most severe damages, particularly in the lower areas of the river. In this flood the Federal Government suffered $100,000 in damage to navigation improvement works in the 1922 flood. Damage to private owners of property was estimated at $20,000.

2.202
The City of Oshkosh is subject to flooding from the Fox River and Lake Winnebago. The properties along this stream and lake have been moderately damaged by the floods of 1922 and 1960. The open spaces in the flood plains which are now, or may come, under pressure for future development are limited.

2.203
The City of Fond du Lac is subject to flooding from the East and West branches of the Fond du Lac River and De Neveu Creek. The properties along these streams have been severely damaged by the flood of 1924. The open spaces in the flood plains which may come under pressure for development are extensive. Spring flooding recurs almost every year. Flooding normally consists of seepage and sewer backup water entering buildings. Usually little damage is caused by these conditions.

2.204
Wolf River Region - The Wolf River contributes practically 70 percent of the Lake Winnebago inflow during flood periods. Flooding of the lakes below Freemont begins almost as soon as Lake Winnebago rises one-half foot above the crest of Menasha Dam and becomes extensive at the stage of 1.25 feet above the crest. Menasha Dam at no time backs up flood waters farther than Fremont. Above Fremont the entire depth of water is due to the volume of water, the condition of the natural channel, and the nearby flat slope of the river.

2.205
The greatest flood known to have occurred on the Wolf River occurred in the year 1888, and since that time other floods have occurred which were within one-half foot of the high water level recorded in 1888. The history of this river, since records have been kept, has shown an average occurrence of more than two floods per year. Although there have been numerous floods along the Wolf River, available information and data indicate that the floods of 1888, 1912, 1922, 1952, and 1960 were floods of the most serious magnitude.

2.206
The main flood season for the Wolf River is in the spring months, particularly in March and April. However, floods have occurred in every month of the year under various circumstances. The severe floods have occurred in March and April as a result of a combination of fast snow melt and rather intense rainfalls, plus the presence of ground frost which increases the runoff. Some of the summer floods have occurred from prolonged rare-occurring rainfalls, sometimes exceeding seven inches in two days, thereby resulting in a high rate of runoff in a short period of time.

2.207
Duration of floods along the Wolf River has varied from a few days to two or three weeks. This, of course, depends on the circumstances causing the floods. Generally, because of prolonged melting of heavy snows accompanied by continuing rains, longer duration floods occur in the spring.

2.208
Several parts of the region suffer from periodic inundation by the Wolf River and its tributaries. Often such inundation reaches damaging proportions and results in losses of property and income. During the past 70 years, there has been at least 50 damaging floods in the region. Few of these have been serious floods. While spring floods reach the greatest volume and highest stage and do the greatest damage to municipal properties, it is the May and June floods which do the most damage to agricultural lands.

2.209
Most of the Wolf Basin's flooding is between the Winnebago Pool and Leeman. About 39,000 acres next to the river between Leeman and New London are subject to frequent overflow. Most of this is low, marshy river bottom not used for agricultural purposes. About half of the flooding is in Outagamie County. Below New London, about 35,000 rural acres are subject to frequent flooding. This land is primarily marshland.

2.210
There are three communities located along the Wolf River from Lake Poygan to Shawano. They are Fremont, New London and Shiocton. All three of these communities have experienced floods in the past. In general, the more serious flooding in the past has occurred in New London, which is situated on the downstream side of the confluence of the Embarrass River

and Wolf River; the Embarrass River flows along the northeasterly side of New London into the Wolf River and the Wolf River flows southwesterly through the business district of New London.

2.211
The region's most damaging flood occurred in March and April of 1922. It inundated over 73,000 acres and caused damages estimated at over $52,000 in the New London area alone. Large sections of the north side of the city, between the Wolf and the Embarrass Rivers, were covered with from one to two feet of water. Basements in homes and commercial buildings were flooded for several days and the streets were undermined and damaged. Rail traffic was discontinued for a period of eleven days. The Wolf River was above flood stage (7.0 feet) at New London for 53 days. Its peak flow reached 15,500 cfs. The maximum inflow into Lake Winnebago, exclusive of precipitation directly into the lake, was about 33,500 cubic feet per second. The inflow exceeded the outflow for 42 days.

2.212
Typically, however, losses have been small and confined to losses of agricultural income resulting from inundation of pasture and cultivated land. Agricultural losses in Outagamie County occur fairly frequently. Some areas experience inundation about three out of every five years. Losses of fish and wildlife habitat also occur as a result of inundation, especially in the marshlands of the Lower Wolf River.

2.213
Flood Damage Reduction Measures - Lake Winnebago acts as a natural reservoir to store flood waters. A U. S. Government dam at Menasha and a privately owned dam at Neenah control the outlets which discharge the water from Lake Winnebago into Little Lake Butte des Morts and the Lower Fox River.

2.214
The Neenah and Menasha dams were constructed by private interests in the mid-1800's. In 1872, the United States was granted the title to the Menasha lock and dam. The Neenah dam remained under private ownership. The sluicing capacities of these dams increased in 1886, 1887, 1922 and 1937. The present sluicing conditions were completed at Neenah in 1922 and at Menasha in 1937. Because of these alterations, the record of lake levels prior to 1937 is not representative of present conditions.

2.215
In accordance with the River and Harbor Act of August 2, 1882, as far as the capacity of the Fox River below Menasha and the security and capacity of the structures will allow, the Menasha and Neenah dams are operated to prevent Lake Winnebago from rising higher than 21 1/4 inches above the crest of the Menasha Dam. This is equivalent to a gauge height of 3.45 feet on the Oshkosh gauge.

2.216
The plan of regulation for flood control is described below. The lake levels given in feet refer to the Oshkosh gauge height.

Spring Floods: In November as soon as navigation is closed, sluice gates at Neenah and Menasha are opened, depending on the level of Lake Winnebago, to begin the drawdown in preparation for the spring thaw. This initial sluicing also permits a sufficient flow to prevent any serious ice buildup in the lower river and consequently avert the formation of ice jams. Sluice gates are regulated in early spring to allow the level of the lake to reach the crest of the dam at Menasha during the first week of April and to a level of approximately 3.0 feet by May 1. All sluice gates and needles are opened whenever the lake inflows indicate that the lake level may exceed 3.45 feet regulatory limit.

Summer Floods: When the spring flows recede (as indicated by the Berlin and New London falling hydrographs) the gates and needles are regulated during the navigation season (May 1 to October 31) to maintain the lake level at about 3.0 feet - providing inflows are adequate to maintain this level. Whenever precipitation occurs, sluice gates are opened as required to limit the lake level to 3.45 feet.

2.217
When water reaches the limit at the Menasha Dam, some land near the Winnebago Pool is flooded. Occasionally, water rises above the 21 1/4 inch limit and floods agricultural lands and summer homes along Lake Winnebago, causing sewers in parts of Fond du Lac and Oshkosh to back up. This is understandable when one realizes that flood waters may be entering Lake Winnebago at a rate of 40,000 cfs, whereas the maximum safe Winnebago Pool discharge rate is 20,000 cfs. Without the regulated storage available in the Lake Winnebago Pool and the controlling dams at the outlet, the natural peak outflow from the lake would at times exceed the controlled maximum outflow of 20,000 cfs. Such uncontrolled outflow, if occurring at the time of heavy local runoff, could have caused extensive downstream damage.

2.218
Floods due to high releases from Lake Winnebago maintain their peaks for a number of days because of the vast storage capacity of Lake Winnebago, while flood peaks from local rainfalls pass through the Lower Fox River system in a few hours. A summary of major Lower Fox Valley floods which have occurred are listed below:

Major Floods in the Lower Fox Valley

Year	Estimated Peak Discharge at Rapide Croche Dam (cfs)	Year	Estimated Peak Discharge at Rapide Croche Dam (cfs)
1922	20,100	1951	20,400
1922[a]	25,500	1952	24,400
1929	20,600	1960	23,600
1943	21,300	1969	16,000
1946	21,300	1973	17,000

[a]*Flood caused by local rainfall. (Base flow of 4100 cfs from Lake Winnebago.)*

2.219
Records of flow on the Fox River since 1898 and on the Wolf River since 1914 indicate that Lake Winnebago floods have recurrence intervals about as indicated below in Table 2.30.

BOTANICAL ELEMENTS

Forest Features

2.220
Curtis[56] and Stearns and Klobriger[57] classify the main forests of the Wolf-Fox porject study area as oak-savanna, southern xeric (oak or oak-hickory) forest, southern mesic (beech-maple) forest, southern lowland (elm, cottonwood, ash, silver maple) forest, and northern mesic (northern hardwood) forest (Table 2.31 and Fig. 2.19). The project area in general contains far less forested land than areas of northeastern Wisconsin and Michigan's upper peninsula, reflecting the emphasis on agriculture in the area. The project area around Lake Winnebago and the Lower Fox River contains less than 12 percent forest cover.[58] The percentage of land covered by forests ranges from 7% in Winnebago County to 34% in Waupaca County.

2.221
Curtis[56] lists the following major trees as characteristic of floodplain forests in the project area: box elder (*Acer Negundo*), silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*), cottonwood (*Populus deltoides*), black willow (*Salix nigra*), and american elm (*Ulmus americana*). Harriman (1975)[59] concurs with this description with the exception that crack-willow (*Salix fragilis*) occurs in the project area

Table 2.30. Lake Winnebago Flood Recurrence Intervals

Recurrence interval, once in years	Estimated inflow to Lake Winnebago c.f.s.
50	35,300
40	34,600
30	33,400
20	31,700
10	28,400
5	24,400
3	21,700
2.5	19,900

Table 2.31. Forest Type Abundance in the Project Area[a]

	Conifers	Oak-Hickory	Elm-Ash-Cottonwood	Maple-Beech-Birch	Aspen-White Birch	Non-stocked[c]	Total	Percent of County Covered by Forests
Brown	3.5[b]	4.4	9.6	15.1	3.5	0.8	36.9	11
Calumet	1.6	7.1	6.5	6.7	2.8	0.8	25.5	12
Fond du Lac	3.8	14.1	11.9	10.1	6.8	2.0	48.7	10
Green Lake	1.7	11.2	4.3	7.0	2.5	1.0	27.7	12
Outagamie	5.3	12.0	21.8	17.3	8.8	3.9	69.1	17
Waupaca	26.5	38.3	21.4	20.9	47.7	9.4	164.2	34
Waushara	26.7	42.5	9.9	11.6	22.9	4.7	118.3	29
Winnebago	0.6	7.5	4.8	6.0	1.1	0.7	20.7	7
Total	69.7	137.1	90.2	94.7	96.1	23.3	511.1	

[a] *J. S. Spencer and H. W. Thorne, "Wisconsin's 1968 Timber Resource," USDA Forest Service Resource Bulletin NC-15. 1972.*

[b] *Numbers are thousands of cubic feet.*

[c] *Commercial forest land on which stocking of trees is less than 16.7 percent.*

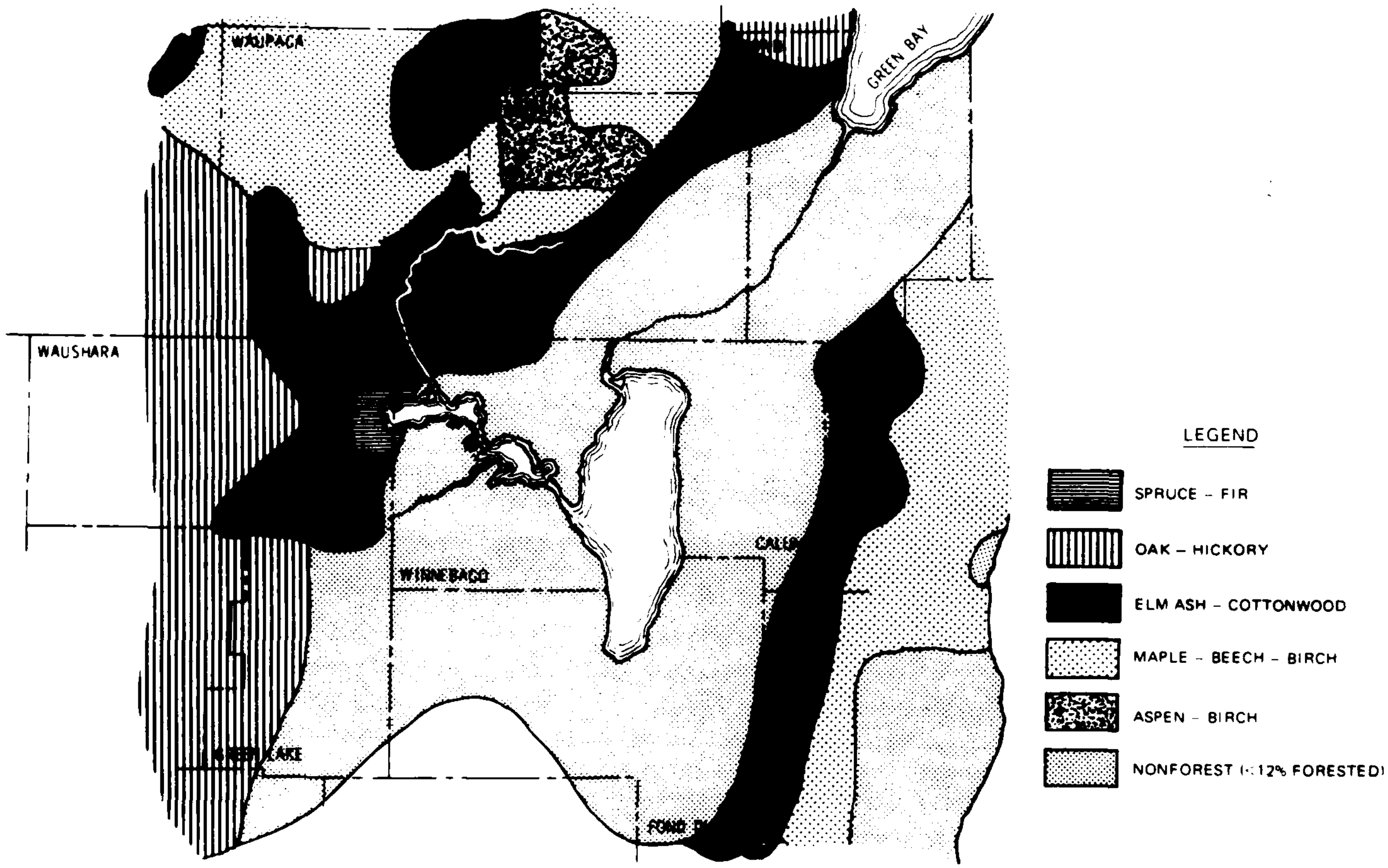

Fig. 2.19. Distribution of Forest Communities in the Fox-Wolf Rivers Drainage Basin. From F. Stearns and N. Kobriger, Vol. 10, "Vegetation of the Lake Michigan Drainage Basin," ANL/ES-40, "Environmental Status of the Lake Michigan Region," April 1975.

instead of the black willow (*S. nigra*). In some parts of the project area these species are more or less equally abundant as dominant species while other areas, such as along the Wolf River north of Fremont, the floodplain forests are composed almost entirely of silver maple (*Acer saccharinum*). The understory of these forests contains large numbers of green ash (*F. pennsylvanica*) and silver maple seedlings. Shrub species common in lowland forests are silky dogwood (*Cornus Purpusii*), red-osier dogwood (*C. stolonifera*), gray-stemmed dogwood (*C. racemosa*), common elder (*Sambucus canadensis*) and the red-berried elder (*S. pubens*). Vine species common in lowland forests are the forest grapes (*Vitis riparia*) and (*Vitis vulpina*), bittersweet (*Solanum Dulcamara*), and virginia creeper (*Parthenocissus vitacea*). If allowed to attain their natural climax, upland forests of the project area would become sugar maple-basswood forests, whereas oak-hickory and ash-northern red oak-elm are dominant in most Wisconsin upland forests. The shrub understory of these woods includes the shrubs mentioned for lowland forests plus the prickly ash (*Xanthoxylum americanum*), gooseberry (*Ribes americanum*), prickly gooseberry (*R. cynosbati*), and poplar (*Populus tremuloides*). Some sandy areas along the Wolf River upstream from the Winnebago-Waupaca County line support a substantial white pine (*Pinus strobus*) forest. Groves of jack pine (*Pinus banksiana*) also occur along the banks of the Wolf River in the New London area.

Marshes

2.222
Extensive marshes are found at various locations along the Fox-Wolf River Basin. A cattail (*Typha*) marsh along the Lower Fox River between Wrightstown and the Little Kaukauna Dam is the largest marsh between De Pere and Lake Winnebago. There are approximately sixty acres of high quality marsh associated with Lake Winnebago in Fond du Lac County. Better known as Supples' Marsh, this tract of wetland is located on the lakefront immediately north of the City of Fond du Lac. The marsh once contained about 425 acres (based on planimetric measurements from 1955 U.S.G.S. 15 minute series map) but has been reduced to its present size as a result of previous municipal sanitary landfill activities. The remainder of wetland areas along Lake Winnebago are relatively small and scattered. Finally, there are several major large marsh complexes in Winnebago, Waushara and Waupaca Counties.

2.223
There are no reliable statistics available showing how much wetlands have changed over the past several decades in the Fox-Wolf Basin, but a measurable decline is evident. The farmer, in his search for increased farm production, has been responsible for much of these losses through wetland drainage. Past government supported drainage programs have also been partially responsible. Land developers and real estate agents have contributed significantly to the loss of wetlands in order to create valuable land areas for development. Municipal government has also helped contribute to wetland losses by allowing lowlands to be used as for refuge and industrial waste disposal purposes. Residential and recreational land developments and project manipulated water levels have also contributed.

2.224
Wetlands are important in providing food, cover, and nesting areas for waterfowl and shore birds; habitat for aquatic furbearers; and spawning areas for fish. In addition, wetlands help reduce runoff, soil erosion, control floods, and improve water quality. A living wetland is viewed as a very valuable natural resource. Decline in regional wetlands is an important matter of concern.

2.225
Probably the most critical wetlands with respect to impacts by the project's maintenance and operation activities are located around the periphery of Lakes Butte des Morts, Poygan and Winneconne. First it seems reasonable, on the face of it, that the construction of dams at Neenah-Menasha in the mid-1800's placed a stress on the marsh by raising the level of water upstream of the dam. Increased amounts of open water resulting from the construction of the first dam on the outlet of Lake Winnebago in 1847 permitted heavy wave action to occur on the lakes. Vegetation was torn loose by waves in the summer, ice heaves in the winter, and the lift of ice and high water in the spring. Since that time, high water has continued to adversely affect the vegetation in these marshes. An old 1916 Corps of Engineer survey of the upriver lakes region indicates that major portions of area lakes were once covered with floating bog. Gradually, this bog area began to lift up and to float due to prevailing high water conditions. Losses began to become quite apparent in the late 1920's. With the disintegration and loss of bog in this area, the underlying peat and muck eroded by wave action moved into deeper areas downstream, thus leaving former marsh areas deeper than when they were covered by aquatic vegetation. While it seems that sudden periods of spring and summer floods have done the most damage to the vegetation by breaking up and flushing out the floating mat but gradually increasing summer pool levels on Lake Winnebago have accelerated overall losses.

2.226
The depth limit at which rooted plants can occur in Lakes Butte des Morts, Poygan, and Winneconne is approximately 4 feet. Autecological studies of rooted vascular aquatics show that the three lakes are floristically and ecologically similar. Rooted aquatics are far more abundant in Lake Butte des Morts than the other two lakes. Lake Poygan is characterized by vast stretches of open water, with relatively few bed of rooted aquatics. Since many suitable habitats (with respect to water depth and bottom type) are available there, bottom fertility, wave action or generally deeper waters may account for the lack of rroted aquatics in Poygan. The most abundant and important rooted aquatic species in these lakes[59] are wild celery (*Vallisneria americana*), the sago pondweed (*Potamogeton pectinatus*) coontail (*Ceratophyllum demersum*), naiads (*Najas* spp.), variegated pond-lily (*Nuphar variegatum*), reed grass (*Phragmites australis*), stiff arrowhead (*Sagittaria rigida*), and bulbrush (*Scirpus acutus*). No endangered plant species are found in the project area. American lotus (*Nelumbo lutea*) is protected under Wisconsin Statutes Sec. 29.546. This species occurs at a very limited number of sites in the project area, occupying substrates consisting mostly of gyttja (fine sediment consisting of organic matter) in 2.6-2.9 feet of water. An area

near Fremont (one mile upstream) contains the only known population of the rooted aquatic, *Butomus umbellatus*, in Wisconsin. This species is an exotic species which was introduced into the U. S. from Europe, and prior to 7 July 1975 was unknown for Wisconsin.[60] Table 2.32 is a list of the rooted aquatic plant species found in Lakes Poygan, Winneconne, and Butte des Morts. Chief swamp types are hardwood swamps (black ash and elm) and conifer swamps (tamarack). Many swamps have black spruce, and this area marks the southern boundary of its range. Sedge, tag alder, and grass are the most common types of marsh vegetation. Some leatherleaf bog and cattail marsh are also present.

Table 2.32. Rooted Aquatic Plant Species of Lakes Winneconne, Poygan and Butte des Morts[a]

	Lake Where Found[b]	Depth Range[c]	Substrate[d]
Ceratophyllum demersum	B, P, W	1.2-3.2	t
Elodea canadensis	B, P	1.2-2.2	c, g, p
Myriophyllum spicatum	B	---	---
Najas flexilis	B, P	1.6-2.2	g
Nelumbo lutea	B, P	2.6-2.9	g
Nuphar variegatum	B, P, W	2.0-4.2	c, g, p, s
Nymphaes odorata	B, P, W	1.4-3.4	c, g, p, s
Phragmites australis	B, W	1.8-4.8	g, s
Polygonum coccineum	P	---	---
Pontederia cordata	B, P, W	2.0-3.4	g, s
Potamogeton natans	B, P, W	1.7-3.4	g, s
Potamogeton nodosus	B, P, W	1.4-3.8	t
Potamogeton pectinatus	B, P, W	1.9-3.9	t
Potamogeton Richardsonii	B, P, W	2.4-4.0	g, s, p
Potamogeton zosteriformis	B, P, W	1.0-3.7	t
Sagittaria latifolia	P	---	---
Sagittaria rigida	B, P, W	1.0-3.5	t
Scirpus acutus	B, P, W	1.0-4.1	g, s
Scirpus fluviatilis	B, P, W	1.0-3.3	c, g, s
Typha angustifolia	B, P	1.2-2.3	c, s
Vallisneria americana	B, P, W	1.3-3.8	t
Zizania aquatica	B, P, W	1.5-4.0	t

[a] *N. A. Harriman, "Autecology of Rooted Aquatic Plants in Lakes Butte des Morts, Winneconne and Poygan," Wisconsin Dept. of Natural Resources, Bureau of Research Project Report. 1970.*

[b] *B = Butte des Morts, P = Poygan, W = Winneconne*

[c] *Depth tolerance values given are in tenths of feet.*

[d] *Substrate types are c = clay, g = gyttja, p = peat, s = sand, t = all bottom types except gravel.*

2.227
As previously stated, it is possible that for many years the regulation of Lake Winnebago has produced significant adverse impacts on the natural habitat of the lakes and river upstream of the Neenah and Menasha dams. Operation of these primary control dams are believed to impact on natural habitats within the Lake Winnebago pool by contributing to high summer pool stages and fluctuating water levels in the lakes and river upstream of these dams.

2.228
Because marshes are a primary problem area which may be associated with Corps project management's activities, the Chicago District has conducted a study to identify the location and extent of existing wetland areas and the rate of vegetational change presently occurring in a 180,000 acre study area which includes the portion of the Upper Fox River and the Wolf River Region between Lake Poygan and Partridge Lake that contains lakes Butte des Morts, Winneconne, and Poygan. The study area, shown in Figure 2.20, includes parts of Winnebago, Waushara, and Waupaca counties.

2.229
The primary objective of this study was to determine from photographic records the general changes in vegetation and land use patterns that have occurred over time in the study area. The study has produced a set of maps and data suitable for assessment of the present (1971) condition of the wetlands through comparison with two previous years (1937 and 1957). The resulting information is useful in defining wetland problems, identifying areas of concern, and determining the quantity and rate of vegetational change occurring in the study area. An inventory of existing wetlands and evaluation of any losses and rates of loss are also a prerequisite to effective management programs.

2.230
Study inventory data is discussed in the following paragraphs. An evaluation of the relationship of fluctuating water levels and an aquatic habitat deterioration in the project area is contained in Section 4.

2.231
Table 2.33 displays the computed gross acreage of the wetlands classification for the Fox and Wolf Rivers-Lakes region of Wisconsin for the years 1937, 1957 and 1971. Of the years investigated, the greatest loss of wetland acreage occurred between 1937 and 1957. This loss was computed to be approximately 24 percent. Using 1937 as the base year the overall loss between 1937 and 1971 was approximately 34 percent.

2.232
These data equate to a yearly rate loss of 606 acres/year for the period between 1937 and 1957 and 372 acres/year for the period between 1957 and 1971. The remaining wetlands would completely vanish in 91 years at a yearly rate of loss of 372 acres/year.

2.233
The gross wetland data compiled for the entire study area mask the situations in the three individual counties that comprise this study area.

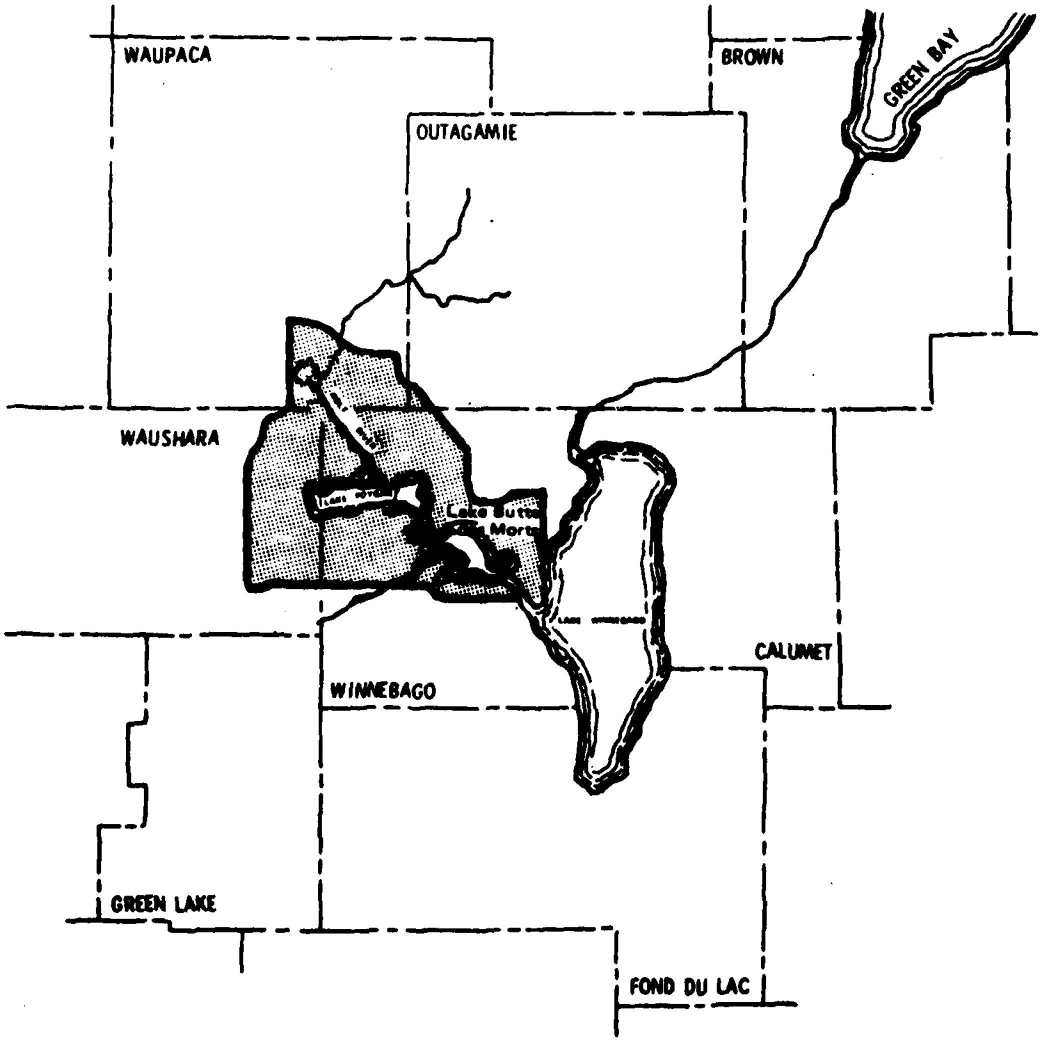

Fig. 2.20. Location of Lakes Vegetation Study Area

Table 2.33. Wetland Acreage Summary, Fox and Wolf Rivers-Lakes Area, Wisconsin

	Year		
Wetland Classification	1937	1957	1971
Pothole	12	1	107
Fresh Meadow	22,315	14,541	11,075
Shallow Marsh	14,536	12,911	11,890
Deep Marsh	4,236	2,679	2,207
Shrub Marsh	1,405	1,294	1,508
Timber Swamp	8,576	7,544	6,975
Total	51,080	38,970	33,762

Summary of Gross Percentage of Wetland Acreage Losses

Years	Acreage Losses	Percentage
1937 - 1971	17,318	34
1937 - 1957	12,110	24
1957 - 1971	5,208	13

Tables D.1, D.2, and D.3, Appendix D, list the acreages computed for each category of wetland for each county area of the three study years and define the problem areas.

2.234
Table D.1 indicates that the wetlands parts of the special study area in Waushara County have remained relatively stable. Wetlands acreage loss from 1937 to 1971 was 8 percent; the loss from 1957 to 1971 was 3 percent. Almost half of the total wetlands acreage mapped in the Waushara County portion is fresh meadow, which has shown a continuous decrease in total acreage; losses from 1957 to 1971 were twice those between 1937 and 1957. While the fresh meadow acreage was decreasing, the acreage of shallow marsh increased over the same time period.

2.235
Table D.2 indicates that the wetland acreage in the special study portion of Waupaca County decreased in total acreage, except for the shrub marsh, which increased in the shallow marsh and timber swamp transition area surrounding Partridge Lake.

2.236
The wetland loss for the Winnebago County portion of the special study area between 1937 and 1971 was 48 percent of the base acreage. Table D.3

indicates a loss of 14,839 acres during this period. The present (1971) wetland acreage is 16,225 acres. Although the loss between 1957 and 1971 was only 20 percent, it still amounted to 3,965 acres. The Waupaca and Winnebago County areas experienced substantial wetland changes and present a management problem.

2.237
Of interest are the shallow areas of Lake Poygan and Partridge Lake, which were exposed in 1957 and show an increase in deep marsh acreage (Tables D.1 and D.2).

2.238
The results of this study indicate that the lakes of the Winnebago Chain (Poygan, Winneconne and Butte des Morts) have increased in area resulting in a loss of wetlands, particularly in Winnebago County. Table D.4 provides an estimate of surface water acreage computed directly from the overlays. Although this method does not correlate directly with total water acreage, it does provide an estimate of wetland losses that directly contribute to the increase in lake area. These data indicate that between 1937 and 1971, Lake Poygan increased in area by 1,020 surface acres. The increase can be attributed mainly to wetland losses in the Wolf River deltaic area (Boom Bay), although unstable wetland areas do occur along the shore line of this lake. The area where Willow Creek and Pumpkinseed Creek enter the lake appears to be relatively stable, except for the mixing area of the two creeks. Mixing can result in considerable erosion during certain periods of the year.

2.239
Lake Winneconne shows a net gain of 402 surface acres (Table D.4); wetland losses have occurred on the northern shore and at Clark's Point. Lake Butte des Morts increased by 417 surface acres between 1937 and 1971, due to wetlands losses in the Fox River deltaic area.

2.240
The total increase in lake surface area of 1,814 acres between 1937 and 1971 is the result of wetland losses primarily in the Wolf River and Fox River deltaic areas. The primary reason for the losses are the floating mats that separate from the main body and float out into the lake.

2.241
The most unstable and therefore most critical wetland areas include both the Wolf and Fox River deltaic areas, the marsh areas along the north shoreline of Lake Winneconne that include Clark's Point, and the area south of Lone Willow Island (Lake Poygan). Wetland losses in Waupaca County are associated with Partridge Lake and the Wolf River. Wetland losses do occur in Waushara County, but there are no large rivers to complicate the problem and the wetlands are relatively stable in comparison.

2.242
Approaches to the wetland loss problem in deltaic areas may be to reclaim some marshes in these areas using appropriate fill material and planting native marsh vegetation or by maintaining optimum lake water levels supplemented with native vegetation plantings and erosion control measures.

ZOOLOGICAL ELEMENT

Terrestrial Fauna

2.243
Mammals - Thirty-eight mammalian species are listed as inhabiting various habitats within the Fox-Wolf River project area.[62] No endangered species are expected to occur within the project area although two species, the white-tailed jackrabbit (*Lepus townsendii*) and the bobcat (*Lynx rufus*), are considered mammals of changing status by the Wisconsin Department of Natural Resources.[61] Long[62] lists several species of the area which are uncommon or threatened largely due to habitat loss.

2.244
The white-tailed jackrabbit is a species of open, grassy areas.[63-65] In northwestern Illinois and southwestern Wisconsin, sand prairie areas support substantial jackrabbit populations.[63] The summer diet consists primarily of grasses, clover, and grain. Buds, bark and small twigs are eaten in winter.[63,64] This species was once an important game animal for its meat but is now protected.[62] Records of *L. townsendii* within the project area are from Brown, Calumet, Fond du Lac, Outagamie, and Waupaca Counties.[62]

2.245
The bobcat (*Lynx rufus*) is a carnivore of wooded river floodplains, often wandering 40-50 miles.[62,63] Dens are found in hollow logs or rock crevices.[64] The diet consists mainly of small mammals (rabbits and mice) and birds. Bobcats are rather uncommon over all of Wisconsin but have been reported from Brown, Calumet, Fond du Lac, Outagamie, and Waupaca Counties within the project area.[62]

2.246
The following game mammals occur in various habitats within the project area: eastern cottontail (*Sylvilagus floridanus*), red squirrel (*Tamiasciurus hudsonicus*), gray squirrel (*Sciurus carolinensis*), fox squirrel (*Sciurus niger*), muskrat (*Ondatra zibethicus*), red fox (*Vulpes fulva*), raccoon (*Procyon lotor*), black bear (*Ursus americanus*), mink (*Mustela vison*), and white-tailed deer (*Odocoileus virginianus*). The white-tailed deer is the most important game species from an economic standpoint. Many people augment their winter meat requirements with venison. The Wisconsin DNR reported approximately 70,000 deer killed in Wisconsin during the one-month long bow and arrow and one-week gun hunting season in 1972. The highest densities of deer in the basin are in Waupaca County in the New London-Fremont area.

2.247
Few data are available on the abundance of furbearing mammals of marshes within the project area. The Wisconsin DNR has gathered data on the relative abundance of muskrats from 1953-1970 on the Rat River, Lakes Winneconne, Little Butte des Morts, and Winnebago.[66] Although muskrats are the most abundant and economically important game mammal of marshes, mink are still found in considerable numbers in certain marshes of the project area.[62]

2.248
Common species inhabiting upland mesic hardwood forests are: fox squirrels (*Sciurus niger*), gray squirrel (*Sciurus carolinensis*), red squirrel (*Tamiasciurus hudsonicus*), the white-footed mouse (*Peromyscus leucopus*), eastern chipmunk (*Tamias striatus*), opossum (*Didelphis marsupialis*), and short-tailed shrew (*Blarina brevicauda*).

2.249
Common inhabitants of wooded floodplain forests are the white-footed mouse and raccoon.

2.250
Oak savannahs and old fields support such common species as the thirteen-lined ground squirrel (*Spermophilus tridecimlineatus*), meadow vole (*Microtus pennsylvanicus*), prairie vole (*M. ochrogaster*), eastern cottontail (*Sylvilagus floridanus*), and woodchuck (*Marmota monax*).

2.251
<u>Amphibians and Reptiles</u> - A total of 16 amphibian and 13 reptilian species inhabit a variety of habitats within the Wolf-Fox project study area.[67] No endangered species occur within the drainage basin. However, the burns leopard frog (*Rana pipiens burnsii*) is classified as a "threatened" species and the blandings turtle (*Emydoidea blandings*) the cricket frog (*Acris crepitans*), and the bullfrog (*Rana catesbeiana*) have been placed in a watch status category. Vogt[68] reports on the amphibians and reptiles expected to occur in Lakes Butte des Morts, Poygan, and Winneconne. The species expected to use these lakes and their associated marshes for reproduction, foraging, and in some cases, hibernation, are listed in Table 2.34.

2.252
Some amphibian and reptilian species can be classified as characteristic of the various vegetation types found in the basin. Upland mesic hardwood forests (beech-maple, beech-maple-oak) provide habitat for the red backed salamander (*Plethodon cinereus*), spotted salamander (*Ambystoma maculatum*), gray tree frog (*Hyla versicolor*), and the milk snake (*Lampropeltis t. triangulum*).

2.253
Lowland floodplain forests (silver maple-cottonwood) provide habitat for the blue-spotted salamander (*Ambystoma laterale*), the american toad (*Bufo americanus*), and Blanchard's cricket frog (*Acris crepitans blanchardi*).

2.254
Oak savannahs and abandoned fields provide habitat for the bullsnake (*Pituophis melanoleucus sayi*), fox snake (*Elaphe vulpina*), eastern garter snake (*Thamnophis s. sirtalis*), eastern hognose snake (*Heterodon platyrhinos*), american toad (*Bufo americanus*), and the tree frog (*Hyla chrysoscelis*).

2.255
<u>Birds</u> - A total of 289 species representing 54 families of birds inhabit or migrate through the Fox-Wolf River project area.[100] These species

Table 2.34. **Amphibians and Reptiles Inhabiting Lakes Butte des Morts, Poygan and Winneconne**[a]

Scientific Name	Common Name
Bufo americanus	**American toad**
Acris crepitans blanchardi	**Blanchard's cricket frog**
Pseudacris t. triseriata	**Western chorus frog**
Hyla crucifer	**Spring peeper**
Hyla versicolor	**Eastern gray tree frog**
Hyla chrysoscelis	**Southern gray tree frog**
Rana p. pipiens	**Leopard frog**
Rana clamitans melanota	**Green frog**
Rana catesbeiana	**Bullfrog**
Notophythalmus viridescens louisianensis	**Eastern newt**
Ambystoma tigrinum	**Tiger salamander**
Necturus maculosus	**Mudpuppy**
Chrysemys picta marginata	**Western painted turtle**
Emydoidea blandingi	**Blanding's turtle**
Chelydra serpentina	**Snapping turtle**
Trionyx spinifer	**Spiny softshell turtle**
Graptemys geographica	**True map turtle**
Thamnophis sirtalis	**Eastern garter snake**
Natrix sipedon	**Northern water snake**

[a]*From R. Vogt, "Long Term Effects of Riprapping on Amphibians and Reptiles," Wisconsin Dept. of Natural Resources, Unpublished report (Memo to files, May 20, 1975).*

occupy a variety of habitats in various seral (successional) stages of old fields, forests, marshes, and urban areas. Many of these species are transients or winter visitors in the project area. Summer residents represent breeding birds of the project area and would be greatly influenced by any habitat changes resulting from the project's operation and maintenance activities. A total of 29 species are likely to breed in old fields (grasslands), 58 in upland and lowland forests and 44 in wetlands.[100] Table 2.35 provides a listing of bird species which breed in wetland areas.

2.256
The following species, occurring mostly as transients, were recorded from the project area and are included on the 1973 Wisconsin DNR list of endangered species in Wisconsin.[61] Double-crested cormorant (*Phalacrocorax auritus*), Cooper's hawk (*Accipiter cooperii*), red-shouldered hawk (*Buteo lineatus*), bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), peregrine falcon (*Falco peregrinus*), and the yellow rail (*Coturnicops noveboracensis*). One other species, the little gull (*Larus minutus*), may be considered in a "threatened position" since it has only recently become established in the United States. Little gulls

Table 2.35. Breeding Birds of Project Area Wetlands[a]

Common Name	Wetlands
Blue-winged teal	DM[b]
Marsh hawk	DM
Short-billed marsh wren	FM[c]
Red-winged blackbird	FM, SM,[d] SS[e]
Brown-headed cowbird	SS
American goldfinch	SS
Black-crowned night heron	DM
Common grackle	SM
Sandhill crane	FM
Common snipe	FM
Wilson's phalarope	FM
Common yellowthroat	FM
Swamp sparrow	FM, SM
Least bittern	SM
American bittern	SM
Mallard	SM, DM
Pintail	SM
King rail	SM
Virginia rail	SM
Sora	SM
Common gallinule	SM, DM
Long-billed marsh wren	SM
Red-necked grebe	DM
Pied-billed grebe	DM
Black duck	DM
Redhead	DM
Ring-necked duck	DM
Ruddy duck	DM
American coot	DM
Herring gull	DM
Forster's tern	DM
Common tern	DM
Black tern	DM
Belted kingfisher	DM
Yellow-headed blackbird	DM
Willow flycatcher	SS
Alder flycatcher	SS
Gray catbird	SS
Brewer's blackbird	SS

Table 2.35. Continued

[a] *Report submitted for this project by Dr. John A. Kaspar, Dept. of Biology, University Wisconsin-Oshkosh.*

[b] *DM = Deep marsh; here water level is 1 to 3 feet and is permanent through the summer; both submergent and emergent vegetation.*

[c] *FM = Fresh meadow; shallow basins usually lacking surface water but with groundwater just below surface; called sedge meadows by many. Sedges and grasses are dominant.*

[d] *SM = Shallow marsh; contains up to a foot of water until midsummer; dominated by Typha, and a variety of grasses.*

[e] *SS = Shrub swamp; shallow basins with waterlogged soils covered with a variety of grasses, sedges, alders, dogwood and willow.*

breed in marshy areas. The known population in Wisconsin in 1975 is 16 birds, including three nesting pairs and six sub-adults, inhabiting the Green Bay area. The type of nesting habitat commonly found throughout the Wolf-Fox area is suitable for the little gull. Among the endangered bird species in the area only two, the double-crested cormorant and red-shouldered hawk, are expected to nest in the vicinity or within the Wolf-Fox project study area. Three breeding colonies of the double-crested cormorant are known in Wisconsin. The colony closest to the project study area is on an island in Green Bay harbor. Although extremely rare, the red-shouldered hawk is expected to nest in lowland forested areas of the project study area.

2.257
To determine the effects of dredge material disposal on bird species composition, birds were censused directly at three previously used disposal sites during late June, 1975. In general, the species found were representative of the successional stage habitat that existed. The species observed are shown in Table 2.36.

Aquatic Fauna

2.258
Aquatic Habitats - The project study area is comprised of essentially two distinct types of aquatic ecosystems, lentic and lotic. The Wolf and Lower Fox River are lotic, while Lake Winnebago and the Upper Fox between Oshkosh and the Wolf River are lentic.

2.259
While the Lower Fox and the Wolf are both rivers, they represent different types of ecosystems. The Wolf River between New London and Fremont meanders, drops about 0.04 feet per mile and is relatively clean.[11] The Lower Fox River, on the other hand, follows fairly straight courses, drops about 4.3 feet per mile and is highly polluted.[14]

Table 2.36. Avian Species Observed at Three Dredge Disposal Sites[a,b]

Common Name	No. Observed[c]
A. Dredge bank below Lock 5 at Kaukauna (spoils approx. 11 yrs old)	
Belted kingfisher	1
Warbling vireo	1
Red-winged blackbird	13 adults, 6 young 3 young in four nests
Common grackle	1
Song sparrow	2
B. Menasha Channel below Lock (spoils approx. 9.8 yrs old)	
Mallard	7 (2 hens nesting)
Eastern kingbird	1
Robin	1
Red-winged blackbird	4
Common grackle	1
Song sparrow	1
C. Wolf River-Boom Cut (spoils approx. 4 yrs old)	
Mallard	8 (1 hen with young)
Killdeer	1
Spotted sandpiper	1
Herring gull	5
Forster's tern	1
Common tern	4
Black tern	1
Mourning dove	2
Eastern kingbird	2
Tree swallow	4
Barn swallow	5
Purple martin	4
Catbird	1
Robin	3
Warbling vireo	1
Yellow-headed blackbird	2
Red-winged blackbird	34
Common grackle	16
Song sparrow	11

[a] *Report submitted for this project by Dr. John A. Kaspar, Dept. of Biology, Univ. Wisconsin-Oshkosh.*

[b] *For a description of the vegetation and dimensions of the disposal sites, see Tables 4.3 and 1.2, respectively.*

[c] *Numbers refer to observations by song or sight during a one-day preliminary and one-day census period for each site.*

2.260
The Wolf River, the Winnebago Pool, and the Lower Fox River differ in their water quality, nutrient status and nutrient sources. The Wolf River has the best water quality in the project area,[11] while the Lower Fox River has the poorest water quality.[14] The highest level of primary productivity occurs within the Winnebago Pool, while the Wolf River probably has the lowest level.[69] The sources of nutrients for the Wolf River are the extensive areas of wetlands, runoff (natural and agricultural) and small amounts of effluents from various small municipalities and industries.[11] In the Winnebago Pool the sources of nutrients are the Wolf River, which supplies 75 percent of the flow to this pool, large areas of wetlands bordering the lakes, runoff (natural and agricultural) and effluents from moderate sized municipalities (principally Fond du Lac and Oshkosh) and their industries. The Lower Fox River receives its nutrients from the Winnebago Pool, which supplies most of the flow in this river, from runoff (natural and some agricultural) and larger amounts of effluents from industries and municipalities.[14] About 90 percent of the point sources of nutrient input (industrial and municipal) in the Lower Fox River is from industry.[70] The nutrient and organic input is so great at times that dissolved oxygen concentrations decrease to nearly zero over 10-20 miles of the river, especially during the summer months, making this water unfit for most organisms.[14,71]

2.261
It is difficult to compare each of the three ecosystems mentioned above in terms of their species diversity because little data exists for similar species groups in each ecosystem. It is apparent, however, that the Wolf River and the Winnebago Pool have much richer biotic communities than does the Lower Fox River. Though data limitations do exist, the species composition and relative abundance or density for phytoplankton, zooplankton, benthos and fish in each ecosystem will be compared as much as possible. The subsequent discussions concerning most of these groups will be primarily qualitative. Better quantitative data do exist on fish species and these will be used where appropriate. The data that are available on the other trophic levels have been collected from only a limited number of sampling stations or only over a short period of time. It is, therefore, difficult to determine if these are representative data. This is particularly true for primary producers such as Chlorophyta, Cchrysophyta, and Cyanophyta, and invertebrates such as cladocerans, Copepoda, and insects. The populations of these organisms may fluctuate erratically over very short periods of time. Therefore, timing for sample collection is critical.

2.262
Reasons, other than the availability of data, for discussing the fish in more detail in this and other sections are their economic importance and their great susceptibility to environmental perturbations. Primary producers, zooplankton, and most benthic invertebrates have relatively short generation times (a capacity for rapid reproduction and large population sizes). Consequently, they usually recover faster from environmental vagaries than fish which have longer generation times, a lower capacity for rapid reproduction, and smaller population sizes.[72]

Since fish are usually unable to adapt to environmental changes as rapidly as these other (lower) species, they are more likely to be adversely affected by the maintenance and operation activities of the project.

2.263
Phytoplankton - Over one hundred phytoplankton species are known to occur in the Fox-Wolf River Basin.[73] The dominant species in this pool are the centric diatoms *Melosira ambigua* (summer), *M. granulata* (summer), *Stephanodiscus niagarae* (autumn), and *S. Hantzschii* (winter). During the summer there are large populations of the blue-green alga *Anabaena* sp., while the pennate diatoms *Asterionella formosa formosa* and *Synedra* sp. are common during the spring and autumn.[73] The present species composition is not well known for the Wolf and Lower Fox Rivers. Undoubtedly there is some similarity since the Winnebago Pool receives a great deal of water from the Wolf River and supplies the bulk of the water for the Lower Fox River.

2.264
Primary productivity data (mg carbon/m^2/day) are available for Lake Butte des Morts and may be characteristic of the Winnebago Pool.[69] These figures ranged from 33.3-5200 with an annual average of 806 and an open water average of 1277 for 1968. Based on data from Epstein et al.[70] this annual primary productivity figure is indicative of polluted waters (350-700 mg carbon/m^2/day compared to 75-250 mg carbon/m^2/day for natural eutrophic water). It is likely that the Wolf River has lower primary production levels because of its lower nutrient levels. The unpublished studies mentioned in the preceding paragraph should be available later this year and should supply these data for the Lower Fox River.

2.265
Sloey[75] indicated that an increase in the volume of phytoplankton in the Winnebago Pool has occurred during the past 60 years (1908-1968). This does not necessarily mean that a change in levels of primary production has occurred since it is really the rate of carbon fixation, rather than standing crop, which is indicative of primary productivity. He did indicate, however, that the numbers of "eutrophic indicator" species has increased, a fact which may indicate a change in the nutrient status in this pool.

2.266
A large amount of emergent and submergent vegetation contributes to the primary productivity in at least two of these aquatic systems (the Wolf River and the Winnebago Pool). These types of vegetation were previously discussed in the botanical section.

2.267
Zooplankton - The dominant zooplankton genera known to exist in the Winnebago Pool during 1971 and 1972 were the cladocerans *Bosmina*, *Chydorus*, *Daphnia*, and *Eurycercus* and the copepods *Cyclops* and *Diaptomus*.[76] During 1971 the cladocera averaged 82% of the total zooplankton, while in 1972 they averaged 58%. *Bosmina*, *Daphnia* and *Eurycercus* were the dominant Cladocera in 1971 and *Chydorus* and *Daphnia* were dominant in 1972.

Cyclops and *Diaptomus* were the only copepoda noted in both years. The three cladocera and two copepoda averaged 93% of the zooplankton in 1971 and the two cladocera and two copepoda genera 96% in 1972. The dominant genus both years was *Daphnia* averaging 49% and 34% of the zooplankton in 1971 and 1972, respectively.

2.268
The total average numbers and range of zooplankton/liter for 1971 and 1972 were 481 (203-1117/liter) and 379 (136-934), respectively. If these densities are representative, they are indicative of the eutrophic nature of the Winnebago Pool. Such densities should provide abundant food for fish such as freshwater drum, white bass and yellow perch, which are known to feed on zooplankton.

2.269
The species composition and density of zooplankton in the Wolf and Lower Fox Rivers are unknown at present. There undoubtedly is some similarity in species composition since the Winnegabo Pool is the recipient of Wolf River waters and the major water supply for the Lower Fox River.

2.270
Benthos - Table 2.37 lists the benthic invertebrate species that are known to exist in the Winnebago Pool and the Lower Fox River. Data of these waters are difficult to compare because they are incomplete. The data for the Lower Fox River are based on a 1957 study[71] with updated 1975 data from the Institute of Paper Chemistry. Those for the Winnebago Pool are based on a study of *Chironomous plumosus* by Hilsenhoff[77] and on studies on the food habits of freshwater drum,[78,79] sauger,[80-82] walleye,[80,81,83] white bass,[84] and yellow perch.[76]

2.271
Of the 48 benthic invertebrate species identified in the 1957 study of the Lower Fox River, 10 species (21%) were pollution intolerant and the remaining 38 species (79%) were either pollution tolerant or very tolerant. Table 2.38 indicates that all of the intolerant species identified in the 1957 study occurred only in the upper part of the Lower Fox River and that, generally, greater numbers of the tolerant and very tolerant species occurred in the upper part than in either the middle or lower parts. The lower part of the Lower Fox River had the lowest species composition (2 species) and abundance (1-10 organisms/sample). Pollution effects were (and continue to be) much greater in this part of the river than in the rest of the river. This depauperate benthic community was consistent with the poorer water quality found in the lower part of the Lower Fox River. The more recent 1971-1975 studies performed by the Institute have documented the existence of sensitive or intolerate macroinvertebrate forms in virtually all areas of the Lower Fox River under high and moderate flow conditions. Low flow and high temperature periods reduce and in some cases eliminate these sensitive and intolerant forms from much of the river.

2.272
Based on the very limited benthic data from Lake Winnebago,[77] about 3 out of 25 species (12%) are intolerant, which is roughly comparable to the

Table 2.37. Benthic Invertebrate Species Known to Exist in the Wolf-Fox River Basin, Wisconsin

Species	Tolerance	WR[a]	WP[b]	LF[cd]
Arthropoda				
Arachnida				
Hydracarina	*U*	-	*X*	-
Crustacea				
Amphipoda		*X*	*X*	*X*
Gammarus fasciatus	*T*	?	?	*X*
Hyalella azteca	*T*	*X*	*X*	*X*
Cladocera	*U*	-	*X*	-
Copepoda	*U*	-	*X*	-
Decapoda		-	*X*	-
Orconectes sp.	*T*[e]	-	*X*	-
Isopoda		*X*	*X*	*X*
Asellus militaris	*V*	*X*	*X*	*X*
Ostracoda	*U*	-	*X*	-
Insecta				
Belostomatidae				
Abedus sp.	*U*	?	?	*X*
Coleoptera		*X*	*X*	*X*
Elmis sp.	*I*	*X*	?	*X*
Helobdella sp.	*V*	?	?	*X*
Lutrochus laticeps	*U*	?	?	*X*
Stenelmis sp.	*U*	?	?	*X*
Diptera		*X*	*X*	*X*
Anatopynia sp.	*T*	?	?	*X*
Ceratopogonidae	*T*	?	?	*X*
Chaoborus punctipennis	*T*	-	*X*	-
Chironomous decorus	*V*	?	?	*X*
C. neomodestus	*T*	?	?	*X*
C. paganus	*V*	?	?	*X*
C. plumosus	*V*	?	*X*	*X*
Coelotanypus concinnus	*T*	?	*X*	-
Cricotopus sp.	*T*	?	?	*X*
Cryptochironomous sp.	*T*	?	*X*	*X*
C. digitatus	*T*	?	*X*	?
Diamesa fulva	*T*	?	?	*X*
Glyptotendipes sp.	*T*	?	?	*X*
Hydrobaenus sp.	*T*	-?	?	*X*
Microtendipes aberrans	*T*	?	?	*X*
Palpomyia sp.	*T*	-	*X*	-
Paratendipes sp.	*T*	?	?	*X*
Pentaneura sp.	*T*	?	?	*X*
Pericoma sp.	*T*	?	?	*X*

Table 2.37. Continued

Species	Tolerance	WR[a]	WP[b]	LF[cd]
Polypedilium sp.	*T*	?	?	X
Probezzia sp.	*V*	-	?	X
Procladius sp.	*T*	?	X	X
Pseudochironomous sp.	*T*	?	?	X
Psychoda sp.	*T*	?	?	X
Stratiomyia sp.	*T*	?	?	X
Tanypus sp.	*T*	?	?	X
Tanytarsus sp.	*T*	?	X	-
Ephemeroptera		X	X	X
Baetis sp.	*I*	?	?	X
Caenis sp.	*T*	-	X	X
Ephemera guttulata	*I*	-	?	X
Ephemerella sp.	*I*	-	X	X
Hexagenia limbata	*I*	X	X	X
Pseudocloeon sp.	*U*	?	?	X
Stenonema sp.	*I*	-	?	X
Tricorythodes sp.	*U*	?	?	X
Hemiptera		X	X	-
Corixidae	*I*	X	?	-
Megaloptera		-	?	X
Sialis infumata	*T*	-	?	X
Odonata		X	?	X
Anomalagrion hastatum	*I*	-	?	X
Ischnura sp.	*I*	X	?	-
Trichoptera		X	X	X
Hydropsyche sp.	*I*	?	?	X
Cheumatopsyche	*I*	?	?	X
Hydropsyche orris	*I*	?	?	X
Hydroptila waubesiana	*U*	?	?	X
Polycentropus remotus	*I*	?	?	X
Simulium sp.	*T*	?	?	X
Mollusca				
Gastropoda		-	X	X
Amnicola limosa	*U*	?	?	X
Ferressia sp.	*V*	-	?	X
Gyraulus deflectus	*U*	?	?	X
Helisoma sp.	*V*	-	X	X
Lymnea stagnalis	*V*	-	?	X
Physa sp.	*V*	-	X	X
Planorbula armigera	*U*	?	?	X
Pleurocerca acuta	*V*	-	?	X
Valvata tricarinata	*V*	-	?	X

Table 2.37. Continued

Species	Tolerance	WR[a]	WP[b]	LF[cd]
Pelecypoda		-	*X*	*X*
Pisidium sp.	*V*	-	*X*	*X*
Sphaerium sp.	*T*	-	*X*	*X*
Nematoda	*V*	-	*X*	-
Nematomorpha				
Gordius sp.	*T*	-	?	*X*
Platyhelminthes				
Turbellaria		-	?	*X*
Dugesia trigrina	*T*	-	?	*X*
Planaria sp.	*U*	?	?	*X*
Rotifera	*T*[e]	-	*X*	-
Annelida				
Dero nivea	*U*	?	?	*X*
Dina sp.	*U*	?	?	*X*
Glossiphonia complanata	*U*	?	?	*X*
Nais communis	*U*	?	?	*X*
Stylaria lacustris		?	?	*X*

Key: *? - Insufficient data base to determine if species is present.*
U - Unknown.
I - Pollution Intolerant.
T - Pollution Tolerant.
V - Pollution Very Tolerant.
WR - Wolf River
WP - Winnebago Pool
LF - Lower Fox River

[a] J. R. McKersie, J. L. Lissack, R. M. Krill and R. K. Kreuger, "Wolf River *Pollution Investigation Survey," Wisconsin Department of Natural Resources, Madison, 67 p. 1971.*

[b] *W. L. Hilsenhoff, "Ecology and Population Dynamics of Chironomous plumosus (Diptera: Chironomidae) in Lake Winnebago, Wisconsin," Ann. Ent. Soc. Amer. 60(6):1183-1194, 1967. Also see References,* .

[c] *R. H. Scott, G. F. Bernauer and K. M. Mackenthun, "Drainage Area 11A-Stream Pollution Lower Fox River." State Board of Health, Madison, Wisconsin. 47 p. 1957.*

[d] *From an Institute of Paper Chemistry listing of macroinvertebrate species found on artificial substrate samplers in the Lower Fox River during 1975.*

[e] *R. W. Pennak, "Freshwater Invertebrates of the United States," Ronald Press Company, New York. 769 p. 1953.*

Table 2.38. **Number of Organisms per Sample for Benthic Species Occurring in Parts of the Wolf and Lower Fox Rivers**

		Number of Species								
		Lower Fox[a]			Wolf River[a]					
		1957[b]			1974[c]			1971[d]		
Category	Organisms per Sample	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Lower	Middle
Pollution intolerant	1-10	10	0	0	0	0	0	6	3	0
	1-25	0	0	0	0	0	0	0	0	0
	1-100	0	0	0	0	0	0	0	0	0
Pollution tolerant	1-10	23	4	1	0	1	1	2	3	2
	1-25	4	1	0	0	0	0	0	0	1
	1-100	2	0	0	1	0	0	0	0	0
	1-100+	0	1	0	0	0	0	0	0	0
Very pollution tolerant	1-10	3	3	1	1	1	1	1	2	2
	1-25	2	3	0	0	0	0	0	1	0
	1-100	1	1	0	0	0	0	0	0	0
	1-100+	1	0	0	0	0	0	0	0	0

[a] *"Upper" is from River Mile 24.5 to 39.6. "Middle" from 12.1 to 24.4. "Lower" from 0 to 12.0.*

[b] *From R. H. Scott, G. F. Bernauer, and K. M. Mackenthun, "Investigation of Pollution on the Lower Fox River during 1955 and 1956," Wisconsin State Board of Health, Madison, 1957.*

[c] *From D. C. Wiesenel, "Results of Biological Investigations on the Lower Fox Drainage Basin #113." Intradept. memo #3200, Wisconsin Department of Natural Resources, Madison, Feb. 18, 1975.*

[d] *From J. R. McKersie et al., "Wolf River Pollution Investigation Survey, April 1971," Wisconsin Department of Natural Resources, Madison, 1971.*

upper part of the Lower Fox River. In this study Hilsenhoff recorded several benthic species and their densities at four stations in Lake Winnebago over a four-year period (1961-1964). The overall average density of benthic organisms for this period was about 9800 organisms per square foot. Of this, roughly 93% (9140/sq ft) were Crustaceans including Cladocera, Ostracoda, and Copepoda in ascending order of abundance. Chironomid larvae, consisting of at least six species, were second in abundance and represented about 4.6% (455/sq ft) of the total density. Clams from the family Sphaeriidae were third in abundance and represented about 01.6% (104/sq ft) of the total density. Three species of leeches were fourth in abundance, and represented about 0.6% (61/sq ft) of the total density.

2.273
If these numbers are representative of the entire Winnebago Pool, they indicate a substantial source of food for fish species known to feed on these organisms, including lake sturgeon,[85] carp,[77] and freshwater drum. The high numbers of these organisms are also indicative of enriched waters.

2.274
Fish - As exemplified in Table 2.38, a rich fish fauna exists within the project waters. Of the 82 species that are known to exist, 22 are sport fish and three are of major commercial importance. The remaining 57 species are either forage fish or are rough (undesirable) fish of lesser commercial importance. Five of these species are of possible legal importance since they are either on the National Endangered Species List[86] or the Wisconsin Endangered Animal List.[87] The lake sturgeon is on the national list while the greater redhorse (endangered), pugnose shiner (endangered), and river redhorse (changing status) are on the Wisconsin list. The list of species for the Lower Fox and Wolf Rivers are sketchy since no surveys have been made of the Wolf and only a preliminary survey has been made in the Lower Fox.[88] As shown in Table 2.39 the meager data that are available for the Wolf have been extracted from a number of reports as anecdotal information.

2.275
Low water quality has resulted in annual fish mortalities as far back as 1925 for the Fox River. During the months of late June to early September, high temperatures and low flow can cause very low levels of dissolved oxygen over 10 to 20 miles of the Lower Fox River. Levels of DO below 1 mg/l are not uncommon. This level of dissolved oxygen virtually excludes the possibility of resident fish populations in these stretches of the river. However, fish populations in the Fox River and South Green Bay (with emphasis on the two and one-half mile section of the Fox River downstream from the DePere Dam) sampled in a recent survey indicate that the Fox River fishery is far more diverse than is generally thought.

2.276
Data collected by the Wisconsin Department of Natural Resources in a preliminary 1973-1974 survey investigation recorded 45 fish species with bullhead spp., carp, white bass, and white sucker accounting for approxi-

Table 2.39. **Fish Species Known to Exist in the Fox-Wolf River Basin, Wisconsin**

	Species	Status	System WR	UL[a]	LW[b]	LF[c]
Petromyzontidae						
Chestnut lamprey	*Ichthyomyzon castaneus*			-	X	
Silver lamprey	*I. unicuspus*			X	X	
Acipenseridae						
Lake sturgeon	*A. fulvescens*	EN	X[d,e]	X	X	X[d]
Lepisosteidae						
Longnose gar	*Lepisosteus osseus*			X	X	
Shortnose gar	*L. platostomus*			X	X	X
Amiidae						
Bowfin	*Amia calva*			X	X	X
Clupeidae						
Alewife	*Alosa pseudoharengus*			-	-	X
Gizzard shad	*Dorosoma cepedianum*			X	X	X
Salmonidae						
Rainbow trout	*Salmo gairdneri*			-	X	
Brown trout	*S. trutta*			-	X	
Brook trout	*Salvelinus frontinalis*			-	X	
Lake trout	*S. namaycush*			-	X	
Hiodontidae						
Mooneye	*Hiodon tergisus*			X	X	
Umbridae						
Central mudminnow	*Umbra limi*			X	X	
Esocidae						
Northern pike	*Esox lucius*		X[f]	X	X	X
Muskellunge	*E. masquinony*		X[e]	X	X	
Cyprinidae						
Stoneroller	*Campostoma anomalum*			-	X	
Northern redbelly dace	*Phoxinus eos*			-	X	
Carp	*Cyprinus carpio*		X[g]	X	X	X
Hornyhead chub	*Nocomis biguttatus*			-	X	
Golden shiner	*Notemigonus crysoleucas*			X	X	
Pugnose shiner	*Notropis anogenus*	EW		X	X	
Emerald shiner	*N. atherinoides*			X	X	
River shiner	*N. blennius*			-	X	
Common shiner	*N. cornutus*			X	X	

Table 2.39. Continued

Species		Status	WR	UL[a]	LW[b]	LF[c]
Blackchin shiner	*N. heterodon*			-	X	
Blacknose shiner	*N. heterolepis*			-	X	
Spottail shiner	*N. hudsonicus*			X	X	
Rosyface shiner	*N. rubellus*			-	X	
Spotfin shiner	*N. spilopterus*			X	X	
Sand shiner	*N. stramineus*			-	X	
Mimic shiner	*N. volucellus*			-	X	
Pugnose minnow	*N. emiliae*			-	X	
Bluntnose minnow	*Pimephales notatus*			X	X	
Fathead minnow	*P. promelas*			-	X	
Longnose dace	*Rhinichthys cataractae*			-	X	
Creek chub	*Semotilus atromaculatus*			-	X	
Catostomidae						
Quillback	*Carpiodes cyprinus*			X	X	
White sucker	*Catostomus commersoni*			X	X	X
Lake chubsucker	*Erimyzon sucetta*			X	X	
Bigmouth buffalo	*Ictiobus cyprinellus*			-	X	
Spotted sucker	*Minytrema melanops*			X	X	
Silver redhorse	*Moxostoma anisurum*			X	-	
Golden redhorse	*M. erythrurum*			X	-	
Shorthead redhorse	*M. macrolepidotum*			X	X	
Greater redhorse	*M. valenciennesi*	*EW*		X	X	
Northern hogsucker	*Hypentelium nigricans*			X	-	
Ictaluridae						
Black bullhead	*Ictalurus melas*			X	X	X
Brown bullhead	*I. nebulosus*			X	X	
Yellow bullhead	*I. natalis*			X	X	
Channel catfish	*I. punctatus*			X	X	X
Flathead catfish	*Pylodictis olivaris*			X	X	
Stonecat	*Noturus flavus*			-	X	
Tadpole madtom	*N. gyrinus*			-	X	
Cyprinodontidae						
Banded killifish	*Fundulus diaphanus*			X	X	
Gadidae						
Burbot	*Lota lota*			X	X	X
Gasterosteidae						
Brook stickleback	*Culaea inconstans*			X	X	
Percopsidae						
Trout-perch	*Percopsis omiscomaycus*			X	X	

Table 2.39. Continued

	Species	Status	WR	UL[a]	LW[b]	LF[c]
Percichthyidae						
White bass	*Morone chrysops*		X[e]	X	X	X
Yellow bass	*M. mississippiensis*			X	X	
Centrarchidae						
Black crappie	*Pomoxis nigromaculatus*			X	X	X
Bluegill	*Lepomis macrochirus*			X	X	X
Largemouth bass	*Micropterus salmoides*		X[e]	X	X	X
Pumpkinseed	*L. gibbosus*			X	X	X
Rockbass	*Ambloplites rupestris*			X	X	X
Smallmouth bass	*M. dolomieui*		X[e]	X	X	
White crappie	*P. annularis*			X	X	
Percidae						
Banded darter	*Etheostoma zonale*			-	X	
Blackside darter	*Percina maculata*			-	X	
Fantail darter	*E. flabellare*			-	X	
Iowa darter	*E. exile*			-	X	
Johnny darter	*E. higrum*			-	X	
River darter	*P. shumardi*			-	X	
Log perch	*P. caprodes*			-	X	
Sauger	*Stizostedion canadense*			-	X	
Walleye	*S. vitreum vitreum*		X[h]	X	X	X
Yellow perch	*Perca flavescens*		X[h]	X	X	X
Sciaenidae						
Freshwater drum	*Aplodinotus grunniens*			X	X	X
Cichlidae						
Mozambique mouthbrooder	*Tilapia mossambica*			-	X	
Cottidae						
Mottled sculpin	*Cottus bairdi*			-	X	

Key: EW = Wisconsin Endangered Species
EN = National Endangered Species
CSW = Wisconsin Changing Status Species
UL = Upper Lake including Butte des Morts, Poygan and Winneconne
WR = Wolf River
LW = Lake Winnebago
LF = Lower Fox River to De Pere Dam
X = Present
\- = Absent

[a]From personal communication with John J. Weber, Regional Fish Biologist, Wisconsin Department of Natural Resources, Oshkosh, Wisconsin.

Table 2.39. Continued

[b]From G. R. Priegel, "A List of the Fishes of Lake Winnebago," Research Report No. 27 (Fisheries), Wisconsin Dept. of Natural Resources, Madison, 1967.

[c]From Lee T. Kerner, "Fishery Investigations on the Lower Fox River and Green Bay in 1973-1974," Wisconsin Department of Natural Resources, Green Bay.

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[f]From G. R. Priegel, "Movement and Harvest of Tagged Northern Pike Released in Lake Poygan and Big Lake Butte des Morts," Research Report #29 (Fisheries), Wisconsin Dept. of Natural Resources, Madison, 1968.

[g]From G. R. Priegel and D. W. Morrissette, "Carp Migration in the Lake Winnebago Area." Bureau of Fish Management Report No. 42, Wisconsin Dept. of Natural Resources, Madison, 1971.

[h]From G. R. Priegel, "Reproduction and Early Life History of the Walleye in the Lake Winnebago Region," Technical Bulletin No. 45, Wisconsin Dept. of Natural Resources, Madison, 1970.

mately 80 percent by number of 23,202 fish examined over the two year period.[88] Other common species included the black crappie, perch, walleye, and channel catfish. Still other less abundant species were reported in increasing numbers and chinook salmon were observed clearing the DePere Dam and foraging upriver during the fall spawning run.

2.277
It is an encouraging sign that the fishery in the upper and lowermost pools of the Fox River has improved during the last few years. Despite continuing improvements in stream water quality, the Fox River nevertheless contains a very marginal fishery at the present time. Fed from the fish rich Great Lakes downstream, as well as the receiving immigrants from the Winnebago Chain, this fishery survives as long as surface runoff provides a sufficiently large volume of water in the stream.

2.278
Seventy-six species belonging to 22 families are now present or have been reported in the past in Lake Winnebago.[92] The families Cyprinidae (minnows), with 21 species, and Percidae (perch) with a total of 10 species, contribute the largest number of species to the lake. The Ictaluridae (catfishes) and Centrarchidae (Sunfishes), each with 7 species, and the Catostomidae (suckers) with 6 species are also well represented.[92] Some species, like the members of the trout family Salmonidae, do not exist in the lake on a yearly basis but are migrants from Big Green Lake or trout streams flowing into the Wolf or Fox Rivers.[92] The more important and abundant game fish species are walleye, saugee, yellow perch, lake sturgeon, and white bass. The most important commercial species is the freshwater drum. Based on commercial data, substantial carp populations exist in the Winnebago Pool and the Wolf River.

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SECTION 3

RELATIONSHIP OF THE PROPOSED ACTION TO LAND-USE PLANS

INTRODUCTION

3.01
In order to determine the Federal Project's relationship to area land use plans and policies, the various types of land use adjacent to the project streams and lakes were investigated, and discussions with the local and regional land-use planning and policy-making agencies were undertaken.

TYPES OF EFFECTS

3.02
The existence of a navigable waterway affects land use in direct and indirect fashions. Direct effects resulting from proposed operation and maintenance programs are: 1) the disposal of dredged materials removed during maintenance of the navigation channels, and 2) the fluctuation of water levels and water flows, both upstream and downstream, due to operation of the dams. The direct effects of disposal of dredged materials are covering of existing land or the creation of new land if open water disposal or marsh filling is done. The direct effects of adjustment of flows and changing of water levels are the variable exposure of land areas, changes in hydroelectric power generation, and shoreline movement.

3.03
In addition, indirect effects of the project on land use can occur due to three project related activities: 1) commercial navigation, 2) recreational navigation, and 3) water-flow control. Since commercial navigation has almost totally ceased on the Lower Fox River, Wolf River, or the lakes between the two rivers, this type of indirect effect can be ignored.

3.04
Recreational boating activity, which is prominent on the project area streams, tends to support many businesses such as marinas, motels, fishing and bait shops, boat equipment sales, rental and repair shops, etc. Also, the area tends to become developed for recreational use due to the existence of vacation homes, lakeshore suburbs, and commercial establishments that cater to the needs of permanent and transient populations. Water-quality degradation, increased recreational activity, and loosely controlled waterfront development may in the long run discourage other types of land use that would otherwise make use of the water resource.

3.05
The flow of the Lower Fox River is affected by the control of storage in the Lake Winnebago pool as authorized by various Congressional acts. This regulation is of such importance to municipal, water power, navigation, and general riparian interests along the river, and around the lake, that Congress has enacted several special acts to require and set limits for regulation. In the absence of this regulation there is little doubt that much of the present intensive development along the lower river and around the lake would not have occurred.

EXISTING RELATIONSHIPS

3.06
The limited, but continuous, requirement for dredged material disposal sites can, in some cases, compromise the land use of an area, while in other cases it can complement existing or newly proposed land use. If the disposal of dredge materials constitutes the filling of floodplains or natural areas, both physical and ecological damage may result. On the other hand, if a proper selection of disposal sites is made, the filled sites can become more useful for man while at the same time avoiding significant adverse impacts to ecosystems. Much of the shoreline of the Wolf River is not suitable for human habitation and development because of frequent and often severe flooding. These areas are, however, prime natural marsh areas and as such are essential spawning and feeding habitat for fish, waterfowl, and other components of the natural ecosystem. Thus, any disposal sites in this region must be carefully selected to minimize impacts to the natural system.

3.07
The shoreline of the central or lake region contains natural areas (marshes frequented by waterfowl); developed areas including city and state park lands, vacation homes, year-round homes, and industrial sites; and undeveloped land. Disposal sites for dredged materials in this area must be selected to avoid conflict with both human and natural utility and, if possible, used to increase the utility of the disposal site itself.

3.08
Disposal of dredged material in the Lower Fox River region is a difficult and sensitive problem because of the close proximity of urban and industrial zones along the river from the Neenah and Menasha dams to the area beyond Kaukauna and through the city of De Pere. In these regions, disposal is generally predicated on increasing human utility of the disposal sites while avoiding conflicts with the existing and proposed plans of the riparian landowners and communities.

3.09
In meetings with the public planning and policy making agencies, as well as with representatives of industrial concerns, it was evident that the riparian rights and water user interests are many and varied, and that some of these rights and interests are in direct conflict.

3.10
In addition to its primary navigation function, control of the water levels in Lake Winnebago and its upstream connected lakes provides important flood control benefits to riparian property interests. During winter, the impounded lakes are normally lowered below dam crest height to provide storage capacity for snow melt and spring rains. This action has the added advantage of reducing the damage potential to the natural shoreline features and shoreline properties (houses, dock, etc.) of wind-driven ice during the spring breakup. The water which is released but which is in excess of the steam flow required for hydropower is a lost resource.

3.11
Low summer flow through the Fox River Valley below the Neenah and Menasha dams can be disadvantageous to the industrial interests of the valley by reducing process water availability and effluent discharge dilution capacity, often required for compliance with water quality standards. While some operating techniques of the dams on the Lower Fox River satisfy some interests, these same techniques can adversely affect the utility, plans and policies of other interests. It is important to note that the present method of operation is not without its impacts, but the potential impacts are widely recognized and understood features of the present method of operation. They are, therefore, anticipated by the local planners and normally considered in present planning and policy making activities.

3.12
There is no demand for commercial navigation. Therefore the continued operation and maintenance of the project navigation channels is directed to recreational navigation. Since no significant increases in associated types of economic development (marinas, commercial facilities, etc.) above and beyond the normal growth patterns already established are expected, no changes in land-use plans policies regarding location or degree of such development should be required.

3.13
The cumulative effects of waterway operations and maintenance, navigation, and waterfront development on water quality are not expected to change from present conditions as the project does not include any changes in existing causative factors.

COORDINATION WITH EXISTING PLANS

3.14
Different types of effects on land use adjacent to the Fox River have been investigated and coordinated with land use planning agencies in preparation of this EIS to identify and resolve conflicts with formal land use plans. From discussions with local planning agencies, it is concluded that all current planning activity in the project study area is predicated on the assumption that the Corps of Engineers will continue to operate and maintain the Fox River project in accordance with project authorization. Since no changes in the methods and techniques of

operation are proposed by the Corps at this time, no adverse impacts to the existing public land-use plans and policies in the study area are anticipated.

3.15
While there are no known conflicts between the proposed action and currently established land use plans in the project area, this report has identified various conflicts and problems of water resource management in the region. These have often been found to be highly complex and interrelated. Furthermore, the demand on the water resource is intensifying and as use demands increase, conflicts of interest will become greater and more widespread.

3.16
It is clear that an optimal solution to these problems can only be found by adopting a broad, comprehensive approach to water management and that adoption of an overall approach to water management focuses attention on the need for greater cooperation and coordination of development and management efforts within and between various levels of Federal, State and local government. As previously indicated, certain major resource management planning studies are currently in progress. The Chicago District is participating in these studies. It is possible that the resulting future management plan, policies and objectives of these studies may lead to some important recommended modifications to the authorized purposes, features, and operational management of the existing Federal project in the future. It must be noted, however, that while an alternative method of apportioning water use could be recommended, resource conflicts will inevitably continue to occur as long as project area water resources continue to provide multiple use benefits to such a wide range of diversified activities. Such modifications may also require authorization by the Congress.

SECTION 4

PROBABLE IMPACTS OF THE PROPOSED ACTION ON THE ENVIRONMENT

INTRODUCTION

4.01
The proposed action will affect both the natural and the man-made environment. In general, this project will be beneficial to the human environment without creating serious adverse effects on the natural environment. Little or no changes are expected to occur in project land and water uses due to the project.

4.02
The impacts of the proposed and ongoing activities will depend on the type of action and location where each is carried out. For example, dredging is conducted in all three regions of the project area (i.e., the Wolf River region, the Central or Lake region, and the Lower Fox River region). Since the site characteristics are different in each region, the expected impacts will also be different. In addition to dredging, flow regulation is carried out on the Lower Fox River by adjusting gates in the dams, particularly those at Neenah and Menasha. On the Lower Fox River, locks are operated for navigational purposes. Maintenance operations are carried out on the dams and locks. The possible impacts of these and other operations are noted in the following sections, and a discussion of the possible effects, both adverse and beneficial, is presented with each impact cited. The impacts associated with each major project components are summarized in a series of environmental impact trees, Figures 4.1 through 4.6. These diagrams show, from left to right, the cause and effect relationships between project components and the physical, biological and human environmental elements. By following the cause and effect pathway, environmental impacts are identified and insight is afforded as to the degree of individual impacts. The impact trees presented cover project dredging, dredge material disposal, lock operation and maintenance, and dam operation and maintenance. An additional impact tree is presented to address the secondary impacts attributable to the navigation made possible by the operation and maintenance of the waterway.

DREDGING AND SNAGGING

Dredge Operations

4.03
The impacts associated with the actual operation of dredging equipment are identified in the major branch of the tree labeled "Dredge [illegible] in Figure 4.1. The smaller branches on the right side of [illegible] discussed individually below as represented by the under[illegible].

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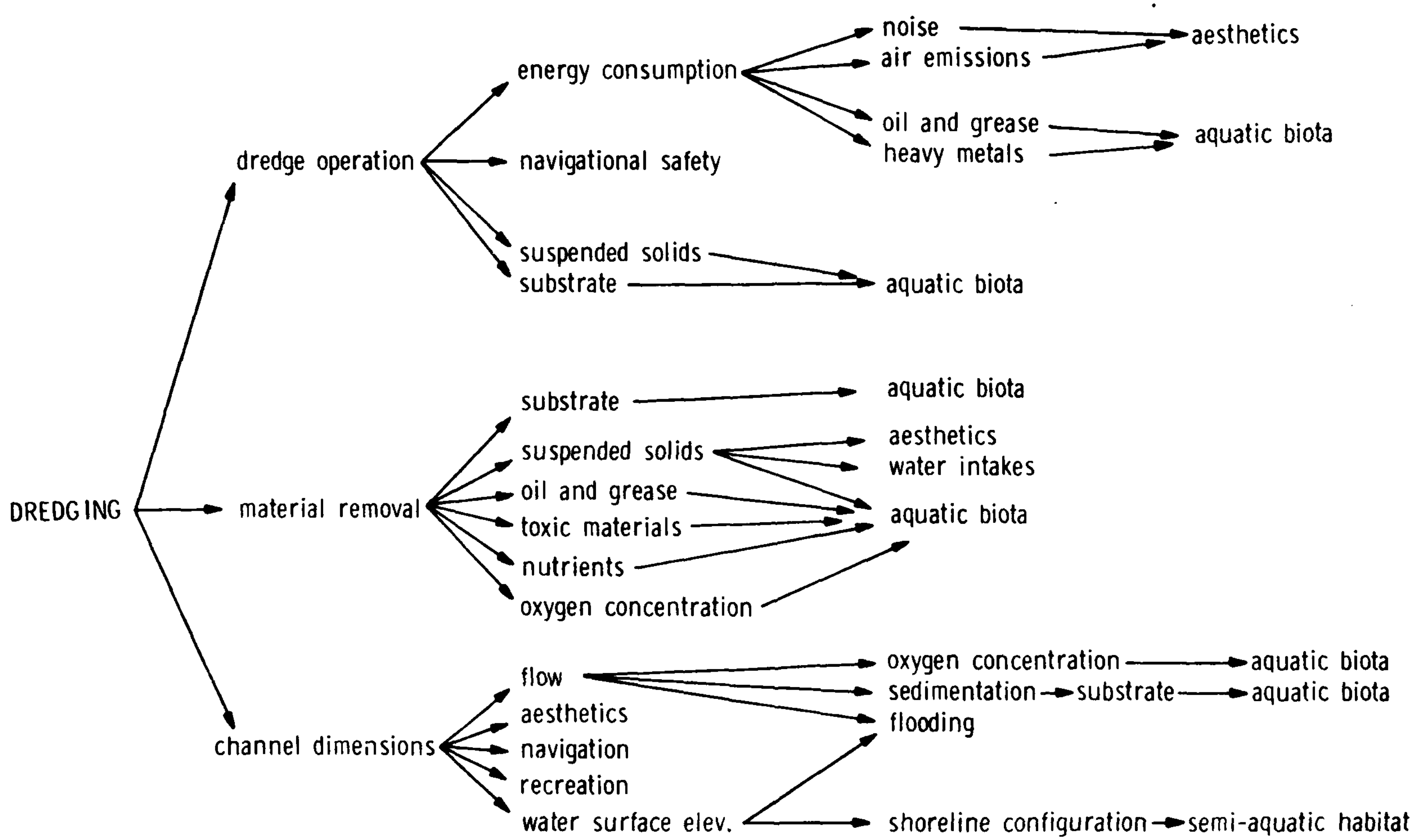


Fig. 4.1. Dredging Impacts

4.04
Energy-Consumption - The one relatively small dredge, a tug, and two self-propelled flat scows proposed for use, will require a total of about 400 horsepower. This energy use is considered inconsequential.

4.05
Noise and Air Emissions - Dredging equipment generates noise and air emissions while in operation. Data are not available which would indicate the exact noise levels produced. However, it is considered that the noise generated by dredging is not great relative to normal background noise levels in the vicinity of most dredging sites. The diesel engines which drive the projects clamshell dredge produce small quantities of air emissions. Considering the intermittent nature of the source and the small quantities involved, this does not amount to a significant air pollution problem. The presence of the dredging equipment and the noise and air emissions generated by its operation causes temporary impairment of riverside aesthetics in localized areas. However, the duration of dredge equipment is generally short. The dredging is not expected to exceed noise and air pollution standards established by the State of Wisconsin.

4.06
Oil and Grease, Heavy Metals - Aquatic Biota - Like any vessel, the dredge engaged in channel maintenance releases small quantities of oil, grease, and most probably heavy metals which enter the water. There is no definite measure of these discharges. But, it is likely that the contributions of the dredging vessel is minor compared to all sources of these pollutants along the Waterway. It is not expected that the oil, grease and heavy metals discharged from these vessels have any significant effect on aquatic biota except as they contribute to overall ambient levels.

4.07
Navigational Safety - Proposed maintenance dredging will allow continued safe navigation throughout the waterway. The presence of the dredge and disposal equipment within the confines of the project areas may lend to more congestion in the harbor and channel areas and may represent an unavoidable hazard for navigation. Appropriate navigation markers will be used, however, and these hazards are temporary in nature and will last only for the maintenance dredging duration. With reasonable care during dredging operations, neither safety nor navigation within the area should be adversely affected by dredging operations.

4.08
Suspended Solids, Substrate - Aquatic Biota - During dredging operations the dredge and scows create turbulence by their movements which causes resuspension of solids in the water column. In addition, the dredge extends supports called spuds to the river bottom while dredging. These spuds disrupt the bottom substrate and stir loose bottom sediment into suspension. These effects on suspended solids and substrate are localized, temporary and produce very minor impacts on aquatic biota.

Material Removal

4.09
The impacts associated with the removal of material as accomplished by dredging and snagging are identified in the major branch of the tree labeled "material removal" in Figure 4.1. The smaller branches on the right side of the tree are discussed individually below as represented by the underlined subheadings.

4.10
Substrate - Aquatic Biota - Maintenance of the Fox River Navigation system entails the periodic dredging of project river and harbor channels. An unavoidable consequence of this action will be the occasional disturbance of channel areas where sedimentation and shoaling have occurred. In conjunction with the sediment-water interface are a number of organisms that constitute the benthic community. The action of removing sediments from channel and harbor bottoms inevitably removes or destroys major portions of this biotic community. The overall amount of disturbance to benthic organisms is quite limited. The action of removing sediments over a ten year period within the project area will eliminate only about a total of 400,000 cubic yards of bottom sediments. Less than two percent of the existing 107 miles of navigable channel will be affected.

4.11
An immediate, short-term impact of excavating sediments from channel and harbor areas is the destruction of benthic organisms contained in the dredged material in the waterway. Certain aquatic organisms, such as plankton, fish eggs, larvae, fry, and other bottom dwellers will suffer a temporary loss of habitat. Some will likely perish as a result of the dredging activity itself or because of increased turbidity. Organisms living in the area adjacent to dredging operations can be smothered by turbidity increases and subsequent precipitation of suspended solids. The benthic organisms most affected are filter feeders and organisms of limited mobility in or near the areas to be dredged. Those more capable of locomotion, however, may simply be displaced from the area until stability recurs. The removal of the organisms should be short-term and local because organisms from adjacent areas should begin to repopulate the dredge area as soon as dredging ceases. Repopulation will increase toward the carrying capacity of the habitat but the rate of repopulation will be dependent on such factors as: the population levels and mobility of organisms in adjacent areas, duration of turbidity and substrate disturbance, current patterns, seasonal conditions, and predation.

4.12
The removal of material from the channel bed by dredging may also have a direct impact on the type of substrate available for benthic organisms. Dredging removes surface sediments from the channel bottom, exposing an old strata to the overlying water, and causing a period of instability. The physical alteration of the interface is expected to generally have only a short-term local impact during the time period that chemical equilibrium is being established. The removal of polluted sediments may even enhance the quality of the aquatic environment by removal of a potential reservoir of pollutants.

4.13
The nature of the newly exposed sediments will not represent a complete alteration of bottom type since those sediments being removed have been deposited upon former river or lake bottom, which was previously exposed to the water interface. The effects of a change in substrate type may be experienced in some areas as a result of material removal. Such changes are dependent upon the type of substrate being removed and the type of substrates in nearby river reaches. Temporary changes may result in areas where sandy or granular material is removed, and the area is covered soon afterwards with silty material.

4.14
Substrate type varies considerably between different segments of the waterway. Coarser materials would be expected downstream of locks. Finer materials usually compose deposit banks at bends in the river. The alluvial fans vary in composition dependent upon the gradient of the tributary prior to its confluence with the Fox River. In general, there should be few permanent alterations of substrate type to the extent that the aquatic worms and insect larval forms which comprise much of the benthic fauna would not be effected other than in very localized areas.

4.15
A final, indirect, short-term impact associated with the removal of material from project channels is the alteration of the aquatic food web in the vicinity of dredging as a result of benthic losses. The temporary reduction in bottom organisms is not critical for the functioning of project area food chains and will not have a serious effect upon fish life.

4.16
Suspended Solids - During material removal processes, considerable turbulence is generated by the dredging equipment. When a clamshell dredge is used to remove bottom sediments from the channel, the amount of suspended silt, sand, and detritus is increased in the vicinity of the dredge. As the bucket is drawn to the surface, water laden with sediments flows through and out from the bucket. The resulting sediment plume is confined to the waters around the dredge, but can be distributed over larger areas, depending upon such factors as wind, wave generated turbulence, and currents. However, the maximum area occupied by the plume is relatively small. The area subjected to sedimentation is likewise small. The increased turbidity has localized effects on substrate and benthos. The magnitude of this increase will vary with the characteristics of the material being dredged.

4.17
Although dredging-caused concentrations of suspended material have not been monitored in the project area, the suspended solids concentration resulting from project dredging activities can be approximated. Table 4.1 provides what may be considered as a "worst case" resultant suspended sediment concentrations due to project dredging activity based on an estimate of the mass of bottom material disturbed and its approximate particle size, distribution, the percent of dredged material that becomes suspended during the dredging operation, and the average water current velocity and water depth within a typical area to be dredged.

Table 4.1. Maximum Sediment Concentrations (mg/l) Expected During Project Dredging Activities

Downstream Distance from Activity (meters)					
300 (984 ft.)	600 (1,969 ft.)	900 (2,962 ft.)	1,500 (4,922 ft.)	2,100 (6,890 ft.)	2,700 (8,859 ft.)
15	6	4	3	2	1

4.18
Table 4.1 is computed for a dredging activity that involves large amounts of sediment released at a relatively constant rate over a long period of time. The turbidity plume is therefore calculated at a steady state and the sediment concentrations decrease with distance from the site. The values in Table 4.1 must be added to the background concentrations. Compared to naturally occurring turbidity levels, these additions would be relatively small, although noticeable.

4.19
The turbidity to be created by project dredging is expected to be of short-term duration and will not contrast with the generally degraded quality of the water throughout much of the project area. Short-term, in this case, refers to the actual period of dredging and the time period following completion of the dredging during which the suspended particles will settle. The duration of project-induced turbidity will vary depending on type of material, weather conditions, etc. Some studies have reported restoration of background turbidity levels two hours after dredged material disposal stopped.

4.20
Material Removal, Water Quality - During the physical process of loosening and removing materials in dredging operations, there is a possibility of exchange of chemical constituents with the river or lake water. There are several areas of concern with dredging operations in general, including oxygen-demanding materials, nutrients, any heavy metals, oil and grease. These items are discussed individually below.

4.21
Water Quality, Aesthetic Characteristics - A water body is aesthetically pleasing if it is free of objectionable deposits at the bottom; free of floating debris, oil scum, and other matter on the surface; and free of substances producing objectionable color, odor, taste, turbidity, or undesirable aquatic life. An increase in these substances can be expected as a result of dredging. This would visually degrade water quality but this would be a short-term effect. Existing water uses should not be significantly affected.

4.22
Water Quality, Water Intake Structures - It is possible that dredging operation in urban areas along the Lower Fox River could impact on industries using river water in the vicinity of project dredging. Increased short-term turbidity and re-suspended solids would present a state of water different than would normally be expected by the user when dredging is not taking place. Such unexpected conditions could vary the quality of effluent from the industrial process. Although the Chicago District is not aware of any problems associated with past dredging operations in this regard, the owners or operators of the intake facility will be notified when dredging is to be performed near their facilities, in order to minimize the possible impact.

4.23
Chemical Exchange Between Water and Sediments - The disruption of sediments may generally be expected to enhance the exchange of chemical constituents. The turbulence increases the surface area of solids exposed to the water and transports interstitial waters to the sediment-water interface. The rate of exchange of material would be expected to increase under these circumstances.

4.24
There may be chemical changes in the microenvironment as the material is disturbed. Changes in oxidation potential, pH, and electrolytic strength may occur. These factors are known to influence adsorption, chelation, and chemical bonding forces, which may be acting to bind chemical constituents to soil particles (Weber, 1972). The specifics of the interchange between sediments and the water environment are not completely understood. Due to this lack of knowledge, Lee (1970) reported that it was almost impossible to predict exchange rates or magnitudes in a system that has not been investigated. Accordingly, the following discussion considers the chemical characteristics of the dredged material, recognizing that a possibility of chemical exchange exists. In the absence of detailed studies and data on the Fox River, it must be pointed out that much of the material which follows is unavoidably theoretical in nature.

4.25
Nutrients - The agitation of bottom solids during material removal may release nutrients from these sediments. McKee et al. (1970) observed greater concentrations of phosphorous associated with increase in water turbulence and turbidity. The turbulence in the stream under study was associated with a change in river gradient. Turbulence generated by material removal would be expected to produce similar results. The chemical analyses of the deposited dredged material samples indicate quantities of nitrogen and phosphorous which could presumably be released during material removal. As discussed in Section 2 and indicated by the water chemistry data in Appendix B, ambient nutrient levels are already excessive throughout much of the project area. Any additional input of nutrients resulting from material removal may increase aqueous nutrient concentrations.

4.26
Oils and Grease - Small quantities of oils and grease may be released from deposits during material removal. The amount of oil and grease which was detected is not great; as such, no substantial problems are indicated.

4.27
Toxic Materials - The resuspension of sediments can cause adsorbed toxic metals, such as mercury, lead, and zinc to be reintroduced into the aquatic environment. The effects of this condition are dependent upon the levels of toxic materials in the sediments to be dredged.

4.28
Some toxic materials were found in the samples of sediments to be dredged (see discussion of sediment tests later in this section). A moderately high level of mercury was found in one sample and lead was detected in another sample. Several samples have high organic contents and nutrient levels. Dredging of these sites will result in release of these materials to the aquatic environment. The exact degree of polluted reintroduction and the nature of the associated impacts are not sufficiently understood at this time.

4.29
It is known that biological transformations may convert elemental mercury into methyl-mercury (Rissanen, et al., 1972) which is believed to be the form accumulated by aquatic organisms. Methyl-mercury is also more soluble than elemental mercury. If the anaerobic bacteria which mediate this reaction are present in the river sediments, it is conceivable that methylation of the mercury might occur in the sediments. Thus, a more soluble form of mercury may be produced in the sediments at a depth sufficient to maintain anaerobic conditions. Material removal operations may release any mercury present in this form.

4.30
The concentrations of lead and zinc are a cause for more concern than the quantities which were observed for mercury. There is a potential toxicity problem which may result during material removal if these metals are released at that time. The zinc appears to pose the greatest source of concern. The duration of these impacts will be short, however, and no significant long-term effects are expected.

4.31
Oxygen Concentration - The dredged sediments may contain substantial quantities of oxygen-demanding materials, as indicated in the data concerning COD. Anaerobic conditions may be present at small depths below the sediment-water interface. In light of Fox River ambient DO levels, the impacts of material removal may present severe localized problems. The amount of oxygen demanding material contained in the sediment will determine the extent of dissolved oxygen depletion resulting from the operation. Jeane and Pine (1975) report that DO could be depressed by 40 to 50 percent near the dredge site. As phosphorous (P), potassium (K), and nitrogen (N) are liberated during dredging, an increased BOD would also be expected.

4.32
At many locations along the Lower Fox Waterway dissolved oxygen is insufficient to support selected sensitive benthic and fish species. Low oxygen concentrations have contributed to the extirpation of several fish species as discussed in Section 2. The oxygen demand of the dredged materials would place an additional stress on the oxygen resources. The elimination or further reduction in DO may have severe temporary effects on organisms in the immediate area of the dredge cut.

4.33
Aquatic Biota - General - Material removal by dredging usually results in direct or indirect alterations of the physical and/or chemical characteristics of a river ecosystem. These alterations may or may not adversely affect the biological components of the system. The degree of effect is a function of many interrelated factors. The biological diversity of the system is one of the most important of these factors, i.e., the more diverse the community, the more stable the system. Stable aquatic ecosystems are better able to resist physical or chemical stresses. Thus, if material removal causes changes in biological abundance and diversity, this will also result in disruption of the population interactions within the aquatic community.

4.34
Some of the major problems resulting from dredged material removal are increased turbidity, actual removal of organisms and substrate, and siltation. Saila, et al. (1968) discussed the potential effects of these changes upon the aquatic ecosystem. The primary direct effect on biological organisms is either mortality or an unfavorable response due to impeded respiratory exchange. Indirect effects include:

1. reduction of light penetration which results in reduced photosynthesis.
2. reduction of visibility of sight-feeding organisms.
3. destruction of fish spawning areas.
4. reduction in some fish food organisms.
5. reduction of vegetation cover.
6. increased organic deposits which result in anaerobic conditions.
7. flocculation of planktonic algae.

4.35
Most of the above impacts will be temporary and local in character but will vary upon the conditions at the time of dredging. Specific ecological impacts will depend on the type of bottom and biota present at the dredge site, the level of previous dredging disturbance, and the volume, area and duration of dredging operations but are believed minor because of the following general project area conditions:

.infrequent requirement for dredging activities
.sparse benthic community
.minimum change in substrate
.short-term chemical and silt changes

.land disposal of polluted dredged material
.little disturbance to feeding areas
.previous dredging history
.reestablishment within one year

4.36
Some problems do exist, however, which could cause temporary ecological imbalances. This would be due to potential toxins such as metals, PCB's and pesticides which may be present in sediments. In addition, there would be negative impacts for a short time because of sediment deposition, low oxygen, and higher turbidity. In other dredging operations, the effects of sediment deposition, turbidity, and chemical disequilibria have been known to affect aquatic life within a half mile of the dredged site (EPA, 1971; Odom, 1970). Oleszkiewicz and Krenkel (1972) have stated that the physical, chemical and biological characteristics of the Ohio River were not significantly altered by dredging in the areas studied. Bardarik et al. (no date) found essentially the same results on the upper Allegheny River. Ketchum (1972) considers initial turbidity, smothering and oxygen depletion after dredging to be brief, generally insignificant disturbances.

4.37
Aquatic Biota - Turbidity - Some of the details of influences of inorganic sediment on aquatic life in streams were reported by Cordone and Kelley (1961). Their studies on fish involved primarily Trout and Salmon but the physiological effects involved are applicable to many species.

4.38
Fish gills may become clogged with silt and particles which usually result in death due to impeded gas exchange efficiency. However, in most instances, indirect damage to fish populations occurs long before fish are directly harmed. Eggs in spawning areas may be smothered by overlying silt. The severity of this effect depends to a large extent on the river flow rates, substrate type and silt particle size. Bottom fauna diversity and abundance may be reduced in several ways. Heavy siltation may smother bottom organisms which in turn reduces the availability of fish food. Siltation may fill in and cover the substrate in interstices which act as surfaces for periphyton attachment and sites for benthoc colonization. Also, increases in turbidity can inhibit certain fish species, especially those that are sight feeders (northern pike and walleye). The potential reduction in food intake could result in less energy for reproduction and could therefore reduce reproductive output. How this reduction in reproductive output would affect recruitment depends on the types of factors limiting the offspring.

4.39
The average turbidities found to be fatal to several freshwater fish species are shown in Table 4.2.

Table 4.2. Average Turbidities Found to be Fatal to Fish

Species	Length of Exposure (days)	Turbidity (mg/l)
Largemouth Bass	7.6	101,000
Pumpkinseed Sunfish	13.0	69,000
Channel Catfish	9.3	85,000
Black Bullhead	17.0	222,000
Golden Shiner	7.1	166,000
Black Crappie	2.0	145,000
Rock Bass	3.5	38,250

Source: U. S. Department of the Interior, Federal Water Control Administration, 1968. Report of the Committee on Water Quality Criteria.

4.40
These data show that fish can tolerate high concentrations of suspended sediment in water. Fish exhibited behavioral reactions at turbidities in the vicinity of 20,000 mg/l (Wallen, 1951, as cited in the National Academy of Sciences, 1973). According to the same source, one species showed behavioral difference at turbidity of 100,000 mg/l. Furthermore, most of the species tested withstood exposure for a week or longer at turbidities higher than 100,000 mg/l. Turbidities of 175,000 to 225,000 mg/l killed the fish within 15 minutes to two hours of exposure. Buck (1956 as cited in the National Academy of Sciences, 1973) conducted experiments on fish growth in 39 farm ponds with a wide range of turbidities. He used the following fish species: largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*) and redear sunfish (*Lepomis microlophus*). The yields of fish as a function of turbidity were reported as follows:

Water Turbidity	Sediment Concentration (mg/l)	Pounds of fish per acre:
Clear pond	<25	161.5
Intermediate	25-100	94.0
Muddy	>100	29.3

The critical concentration for reproduction rates was found to be about 75-100 mg/l for all three fish species. McKee and Wolf, 1969, found that a turbidity level of 200 ppm had no effect upon any age class of fish. However, Cambell (1954) found that at concentrations between 1000-2500 ppm, rainbow trout eggs were destroyed.

4.41
Mobile species of fish migrate or avoid areas being dredged and escape injury. From the preceeding discussion, however, it can be seen that fish species, especially fishes through the fry and fingerling stages, can be adversely affected by dredging caused turbidity if the intensity and duration of the turbidity exceeds the species tolerance limits. The degree of adverse response to turbidity also varies for different overall aquatic conditions.

4.42
Turbidity may also affect temperature relations (Bartsch, 1960). Turbidity changes the water environment by rapidly absorbing radiant energy in the upper layers of the water which reduces the depth of effective photosynthesis and inhibits algae growth. Algae and plankton recover quickly, however, once turbidity levels subside. Submergent vegetation is also inhibited by reduced sunlight. In the spring these rooted plant species initiate growth; and are hindered from continued growth if enough light does not reach the bottom of the bay. In the early stages of vegetative development it is critical that enough radiant energy is available at the bottom so that plants can grow tall enough to be in the areas of effective photosythesis. Some losses will occur and plant life will be displaced for a time.

4.43
The following maximum concentrations of suspended sediments are recommended by the National Academy of Sciences, National Academy of Engineering (1973), for protection of aquatic communities.

High level protection	25 mg/l sediment
Moderate protection	80 mg/l sediment
Low protection	400 mg/l sediment
Very low protection	over 400 mg/l sediment

Aquatic communities in the project area will therefore be afforded a moderate level of protection under "with project" turbidity conditions.

4.44
Aquatic Biota - Resuspension of Pollutants - Increases in suspended solids will have a number of adverse affects upon the aquatic environment. Nutrients such as phosphorous and nitrogen are released into the aquatic system and tend to accelerate excessive growths of algae and other aquatic plants (Biggs, 1968). Zooplankton are also stimulated by organic nutrients in the suspended sediments but may be adversely affected by toxic compounds present in the sediments. Increased algae growth can ultimately lead to low dissolved oxygen levels which are very detrimental to fish and other biota.

4.45
Other adverse effects will result from a reduction of oxygen due to chemical demands. During the dredging process and for a time afterward, organic material at the new sediment-water interface and within the unsuspended sediments, will tend to oxidize and increase the biological oxygen demand over previous background levels. This decreased level of dissolved oxygen can affect both those species that reside within the dredged area and those adjacent to the area.

4.46
Aquatic biota need certain concentrations of dissolved oxygen to maintain their metabolic processes. The reduction of available dissolved oxygen will temporarily disrupt the existing ecological community (Brown, C.L.; Clark, R. 1968). Even a temporary lowering of the dissolved oxygen may be critical for some organisms. Dissolved oxygen would be most serious along the Lower Fox River during the late summer period. The river bottom is especially high in oxygen demanding substances and as these materials are dredged, dissolved oxygen could be reduced to near zero in localized areas.

4.47
In areas with polluted sediments, such as the Lower Fox River, dredging can also increase the amount of toxic substances within the water column.[1] Heavy metals and pesticides that have been dormant in deep sediments may become available for uptake and could pass up the food chain, affecting the viability of the organisms at all levels of the food chain. Although the consequence of releasing toxic metals during dredging operations is not well understood, it would be expected that a higher level of heavy metal concentrations would be suspended in the water following dredging in an area of high metal sediment concentrations (and thus more toxicity to aquatic life) than in an area with lower heavy metal concentrations similarly dredged. Metals are also known to act synergistically or antagonistically on aquatic biota. As metals are stirred up by the dredging process, omnivorous food chains would be negatively affected more than carnivorous.

4.48
Most of the impacts associated with resuspension of pollutants will be temporary and local in character but will vary upon the conditions at the time of dredging. Studies have shown that adverse increases in turbidity, solids, nutrients, COD, heavy metals and decreases in dissolved oxygen are almost totally reduced to pre-dredging levels within 24 hours (Richie and Speakman, 1973).

4.49
Aquatic Biota - Siltation and Loss of Habitat - Dredging and snagging operations in the project waters will cause loss of habitat and increase the amount of suspended solids within the water column.[1] While dredging activities may cause some temporary loss of habitat for benthic organisms, no evidence exists to suggest that any major fish spawning grounds will be affected in Lake Winnebago and the Lower Fox River. The water flow is quite slow in Lake Winnebago and resuspended material should settle out

rapidly within a small area. The Lower Fox River is apparently too polluted to support spawning populations of many fish species. The Wolf River, on the other hand, has extensive areas of spawning habitat for fish and because of this a greater chance of impact exists in this river.

4.50
Dredging and snagging in the Wolf River will cause loss of spawning habitat, such as sand bars, submerged logs and branches, etc., which are utilized by white bass, walleye, and many other species. This loss of spawning habitat would either result in too many fish spawning per unit area of remaining habitat or some fish may be forced to spawn in less desirable habitats. The effect of either of these on recruitment is difficult to assess, since all of the variables that regulate the success of the offspring and juvenile populations are not precisely known. If density-dependent factors, such as competition and predation, are involved, recruitment may actually be increased, providing that a sizable portion of the spawning population is not affected. However, if density-independent factors, such as water temperature, current velocities or water levels, are the main limiting factors, then recruitment will probably be reduced by the loss of spawning habitat. In the absence of firm data it would be safe to assume that destruction of spawning habitat would have at least some adverse effect on recruitment. For yellow perch, at least, there does not appear to be any relationship between survivorship of offspring and water temperature,[2] which is not to say, however, that density-dependent factors may be involved.

4.51
In time the dredged material removed would be replaced by the river and lost fish spawning habitats would be restored. Any aquatic biota lost would also replace itself once this material returns. Refuges for small fish and the offspring of larger fish species created by the shallow water over the sand bars would also redevelop, thus affording protection to these small fish from predation by larger fish. Therefore, any losses due to dredging would probably be short-term ones.

4.52
Increases in turbidity could also affect hatching success if the dredging were done during spawning periods. As the resuspended materials settle out they could cover eggs lying on the bottom and prevent proper oxygen uptake by these eggs. This would be particularly true if dredging of areas with silty bottoms occurs upriver from spawning grounds having sandy bottoms. By elimination of these eggs fewer offspring would be available for recruitment. Records indicate that dredging has been accomplished during those periods when fish spawning, hatching, and larval development would be unaffected.

4.53
Because the amount of dredged material anticipated from the Wolf River is relatively small it is unlikely that any great loss of fish spawning habitat would occur or that the increase in suspended solids would be sufficient to cause major impacts to the various fish populations. However, in order to reduce the impact to the various fish populations, especially those that breed in the Wolf River, dredging should be done during the latter part of the summer when spawning, hatching, and larval

development has ceased for most of the fish species. For these reasons dredging will continue to be performed during those periods when impacts on fish populations are relatively minor.

Channel Dimensions

4.54
The impacts associated with the channel dimensions which result from dredging and material removal are identified in the major branch of the tree labeled "channel dimensions" in Figure 4.1. The smaller branches on the right side of the tree are discussed individually below as represented by the underlined subheadings.

4.55
Flow - Modification of channel dimensions has ramifications for discharge characteristics of the channel. Two changes are apparent: there is a region of increased channel depth, and a small increase in cross-sectional area is available for flow at original river stages. The increased channel depth will support an increased flow rate for the same river stage as well as supply the necessary draft for navigation vessels. In combination with an increased flow cross-section, these larger velocities will result in greater discharges at original river stages.

4.56
No perceptible changes in flow rates of the project waters are anticipated. The fall of the river above the Winnebago Pool preclude such action in the Wolf River region. The controlled flow of the Lower Fox River precludes any perceptible flow changes during normal stage flows, while during high stage (flood) flow conditions the slight change which might result from the depth increases of dredging would be imperceptible compared to the high flow conditions that are present.

4.57
Oxygen Concentration - Aquatic Biota - Inasmuch as river velocities are reduced by channel modification, stream reaeration rates will also decrease. The reduced atmospheric reaeration results from decreased turbulence at the water surface when velocities decrease. The actual dissolved oxygen will not be influenced significantly by channel modification. Therefore, the effects on aquatic biota will be minimal.

4.58
Sedimentation - Substrate - Aquatic Biota - The maintenance of sufficient river depth for navigation purposes has contributed to a general increase in sedimentation rates. As dams are constructed and pool elevations are raised and as dredged material is removed from the channel, the cross-sectional area of the river flow is correspondingly increased. As a direct result, the river velocity decreases as does the river competence. Hence, more of the suspended solids are able to settle to the river bottom. High flow conditions will also tend to scour and deposit additional sediments in the area previously dredged.

4.59
Aesthetics - The maintenance dredging of a navigation channel such as that in the Fox Waterway restores the design channel dimensions in the reach of river dredged. However, there is no actual realignment of the channel. Unlike an original or initial channelization project, the appearance of the river channel from the surface is unchanged by maintenance dredging. Thus, there is no effect on riverside aesthetics from dredging to restore channel dimensions.

4.60
Navigation - The maintenance of channel dimensions is a requisite to the continuance of recreational navigation on the Fox Waterway. To maintain depth clearance for craft using a navigation channel, occasional dredging of the channel is required to remove excess sediments that accumulate wherever the water velocity slows sufficiently to allow suspended solids to settle. Snagging is required to remove accumulated debris. As previously stated, the act of physically relocating these materials can produce several impacts on the water bodies from which they are removed and on the areas where the dredged materials are deposited.

4.61
Recreation - Channel maintenance affects forms of recreation other than boating. Picnicking, hiking, camping, fishing, etc. sometimes become clustered about areas suitable for recreational boating.

4.62
Water Surface Elevation - The channel modification activities will not significantly lower the water surface elevation. These effects will not be significant during periods of high flow, because flood flow rates are much greater than normal discharges. Modification is not expected to supply substantial flood control benefits.

4.63
Shoreline Configuration - Semi-Aquatic Habitat - As noted above, channel modification has only minimal effect on water surface elevation. Hence the effects on shoreline configuration and semi-aquatic habitats from this source are insignificant.

4.64
Flooding - Since channel modification results in increased channel cross-section, larger flows can be accommodated at original river stages. This will result in very small increases in river stage at flood conditions. These effects, however, are very localized.

DREDGE MATERIAL DISPOSAL

4.65
Assessment of the impacts of dredged material disposal and determination of the most suitable methods of disposal is the result of a systematic review and evaluation program in cooperation with the Wisconsin Department of Natural Resources, the U.S. Fish and Wildlife Service, and the Federal Environmental Protection Agency. Table 1.4 provides a list of

mutually agreed upon disposal sites which were reviewed and selected after a June 1976 field evaluation. The locations of listed sites are shown in Figure 1.4 through 1.16.

4.66
Many aspects were considered in the selection and evaluation of potential disposal sites. The sites proposed herein were considered to be the most desirable for use based on proximity to areas being dredged, capacity of the site, site ownership and accessibility, views of state and local officials, other potential uses of the site, and environmental considerations.

Chemical Aspects of Deposited Sediments

4.67
To evaluate the possible undesirable environmental characteristics of dredged materials and determine the suitability of the dredged materials for various beneficial uses, bottom sediment samples were collected at selected project area locations and tested for a number of physical and chemical characteristics.

4.68
The choice of sampling sites was made on the basis of actual project maintenance dredging requirements. The site locations are the numbered locations shown in the charts of Appendix A. Table B.1 (Appendix B) is a list of the sampling sites, which is keyed to the numbers shown in these charts, and contains a description of the nature of the specimens obtained. The 27 samples tested were taken as dredge grab samples. A hard bottom (absence of sediments) prevented collection at three other sites. The samples were placed in plastic bags and refrigerated immediately following collection and during delivery to the analytical laboratories.

4.69
The analyses were performed by the Soils Analysis Laboratory of the University of Wisconsin and by the Wisconsin Alumnae Research Foundation Laboratories. The methods used in these tests are described in Reference 21.

4.70
The particular set of analyses performed on the Fox River project sediments were selected in consideration of the present and past EPA regulations on the basis of expected problems and in consultation with the laboratory personnel directing the analyses. A list of these tests is shown in Table B.2, Appendix B.

4.71
From the test data noted in Table B.3 to B.7, it is expected that sediments taken from the Wolf River (Nos. 25 through 30) will produce no adverse impacts at the anticipated disposal sites. Since these sediments are largely sand, drainage would be rapid and adverse effects minimal. The materials are low in agricultural nutrients.

4.72
With some exceptions, samples taken from the Lake Winnebago harbors and the Lower Fox River contain large amounts of volatile solids (wt. loss on ignition). One sample (De Pere dam) has a high lead content and several others appear borderline. Several samples have high zinc contents and sample No. 20 (downstream of Kaukauna) has a high mercury level. A number of samples exceed the Kjeldahl nitrogen criteria and sample No. 1 (Fond du Lac River) exceeds the oil and grease specification. While the clay content found is not especially high, the high level of organic matter inclusion plus the clay, indicates that sediments from many anticipated dredging sites would be slow to drain and would require extended periods of time before thick beds could be used for agricultural, commercial, or industrial purposes.

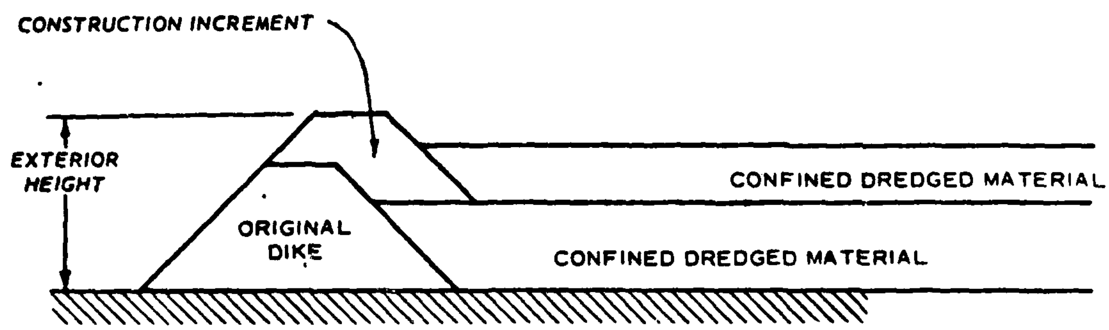
4.73
A perspective of the concentration of the metals Hg, Zn, Pb found in some samples may be gained by a comparison with the concentrations found in sewage sludges which are being used to enrich agricultural lands.[22] The sewage sludge samples used to enrich agricultural lands were found to contain 3.89 ppm of Hg, 110 ppm lead and 320 ppm Zn. With the exception of the lead concentration in one sediment sample, no sediment tested for this project contained more than a fraction of these levels and consequently, disposal of the anticipated dredge materials onto agricultural lands is probably acceptable. At the location where disposal in a confined lagoon is anticipated, runoff water from the dredge materials will be monitored. The high oil and grease sample should not be deposited at disposal sites which directly contact or drain into water bodies. These dredgings should be acceptable for agricultural or fill use, however.

4.74
Although thick layers of many of the sediments tested would be slow to dry out, the high organic content and nutrient levels would make these materials generally useful for agricultural purposes or enhancing revegetation of disposal sites.

General Plan Aspects

4.75
Generally, disposal sites are to be enclosed by dikes using material borrowed from within the dispoasl area (see containment area example Figure 4.2). Enclosure of the areas by dikes in advance of disposal and prompt protection of the dikes by riprapping where exposed to high flows or wave action will be required to maintain the effectiveness of the dikes and prevent erosion. The dikes will be well constructed and will meet the other qualifications in References 17 and 23.

4.76
The purpose of dike containment is to prevent erosion and movement of deposited materials, as well as to confine and control runoff water. Controlled permeation through these dikes is expected to minimize, if



b. Incremental Dike Construction

a. Example Containment Area

Fig. 4.2. Dike Construction

not eliminate, any significant reintroduction of suspended or dissolved solids to the waterway. Generally only a few hundred cubic yards of dredging in one area is required, making the cost of providing special disposal areas relatively high on a unit quantity basis.

Site Specific Features

4.77
The recommended disposal site at De Pere is located along the right canal bank adjacent the De Pere Lock. Although the site is currently owned by the Wells Coal and Dock Company, the City of De Pere is in the process of the obtaining this site for development as a public park. Dredged material disposal at this site is proposed to be undertaken in such a manner so as to create aesthetically pleasing landforms which will enhance future park development.

4.78
The recommended Little Kaukauna site is the headrace above the abandoned papermill next to the Little Kaukauna lock and dam. The potential loss is the approximately 1950 kW (peak) of hydropower which could be obtained at the site. This loss represents an estimated annual energy loss of about 10,600,000 kWh for the approximately 9-ft static head (using the authorized 24-in flashboards) available at this location. This property was abandoned by its former owner, the Kaukauna Water and Electric Department. This location was not considered by the company to be a desirable generating site because it is located outside the company's area of generating activity, and the capital cost to develop the facility is too large for the benefits to be gained.[16] Disposal of dredged material at this location would return the site to a terrestrial habitat somewhat like that which originally existed, while at the same time providing a disposal area which could be used for many years. Filling of the proposed site would have minimum environmental impact. The disposal site would be completely diked or enclosed. The dike would be designed to permanently contain the solid pollutants. Dissolved solids will not be removed; they can only be removed by extensive physical and chemical treatment which is not feasible within the scope of this project. Some soluble pollutants will therefore pass through the dike. The area will be monitored during disposal to insure the effectiveness of the system. A channel to the enclosed area, an unloading berth deep enough to moor the loaded barges carrying the dredged material, and a means of transferring the dredged material from the barges to the dispoasl area are needed.

4.79
Dredged material disposal along the right canal bank at Rapid Croche will be strictly controlled and confined within State of Wisconsin approved site boundaries. The disposal plan will leave undisturbed lowland forested areas as wildlife habitat. Certain large trees within the disposal site will also be retained for bird nesting and cover purposes.

4.80
The Kaukauna site involves the filling of the existing overflow ditch landward of the canal and diverting the existing overflow to the canal

below the 4th lock. Filling of the selected area will not reduce the effective flood flow capacity of the Lower Fox River or have significant environmental impact on fish or wildlife habitat. Existing bank vegetation adjacent to the canal will not be disturbed.

4.81
Disposal activities on the right canal bank at Combined Locks will be strictly controlled and confined within State of Wisconsin approved site boundaries so that lowland forest and marsh areas will not be impacted upon. Special erosion control provisions will be incorporated into disposal site development specifications to prevent adverse impact to a nearby wetland area.

4.82
The proposed disposal site at Little Chute is located along the right canal bank adjacent the Little Chute 2nd lock. The disposal area includes a portion of a previously used municipal landfill site. The disposal plan will have minimal environmental impact due to the presently disturbed nature of the site.

4.83
Because of possible wildlife values associated with the originally proposed site at Cedars lock, dredged material disposal will generally be confined to the lawn area adjacent to the right canal bank. Disturbance of vegetated areas on the northern edge of this site will be limited.

4.84
Attempts to date to locate a State approved disposal site within the vicinity of Appleton have been unsuccessful. A continuing effort will be made to identify satisfactory local sites. In the event that an acceptable local site cannot be secured, it would be necessary to haul dredged materials from this area to a more distant downstream location. In accordance with Corps of Engineers' policy and project authorities, if it is evident during the initial planning of such a disposal operation that substantial additional costs would be incurred, Appleton area dredging operations may be suspended unless local interests agreed to finance the additional costs.

4.85
Dredgings from the Menasha and Neenah channels are to be loaded on trucks and transferred to state approved municipal landfill sites.

4.86
At Calumet Harbor, the Fond du Lac Planning Commission has requested that it be permitted to use dredged materials and has provided a disposal site in an open lawn area of the adjoining County owned Columbia Park. Low lying agricultural land adjacent to the left bank of Pipe Creek, east of Columbia Park and north of the east-west road to the Village of Pipe Creek, is proposed as a future disposal site after the initial, one-time use of Columbia Park.

4.87
Dredged materials at Brothertown and Stockbridge Harbors are to be stockpiled on existing Federal properties for later agricultural or fill use. Ultimate disposal is the responsibility of local interests.

4.88
Dredged materials at Fond du Lac Harbor are to be accepted and distributed by the City of Fond du Lac. An area adjacent the left channel bank is the receiving land site for dredgings from this harbor. The area is bordered by a line of trees on its western edge. The fresh water marsh to the west of these trees will not be impacted upon.

4.89
Disposal of materials from dredging and snagging operations on the Wolf River will be accomplished by transporting the material from scows into trucks located on-shore for disposal elsewhere at specified land areas. It is anticipated that the trucks will be provided by the Waupaca County Highway Commission. Disposal sites for the dredged and snagging materials for the most part will be deposited on agricultural lands. Disposal will not be undertaken in wetland or marshy portions of farm property. Since dredging and snagging requirements to maintain the navigability of the Wolf River vary from year to year, and the plan of disposal is dependent on reaching agreements with private individuals, the Chicago District will undertake advance coordination and field inspection of proposed dredging, snagging, and disposal sites with Federal and State fish and wildlife interests on a case-by-case basis. The Chicago District will also work with the Wisconsin DNR and the U. S. Fish and Wildlife Service in an effort to further examine and develop alternatives and/or means of minimizing anticipated long-term losses to Wolf River fish and wildlife resources. This will require an examination of the recreational navigation and related benefits vs. fish and wildlife losses associated with continued Federal operation and maintenance of the Wolf River navigation system.

Deposition of Material

4.90
The impacts associated with the actual deposition of dredged materials at disposal sites are identified in the major branch of the tree labeled "deposition of material" in Figure 4.3. The smaller branches on the right side of the tree are discussed individually below as represented by the underlined subheadings.

4.91
Shoreline Configuration - Due to the limitations of access of some dredging equipment, material is usually deposited on or near the river shoreline. Consequently, many disposal sites encroach on shoreline areas.

4.92
Aesthetics - Disposal sites near the river shoreline which are in active use will be visible from both river and off-river vantage points in the immediate vicinity. Depending upon the quantity and frequency of material deposited, this can amount to a noticeable impairment of riverside aesthetics. This will especially be so during the period of time which dredged materials consolidate and the disposal site develops a vegetative cover. Based on past experience with similar disposal sites, expenditure of funds to accelerate the natural revegetation process is not considered warranted.

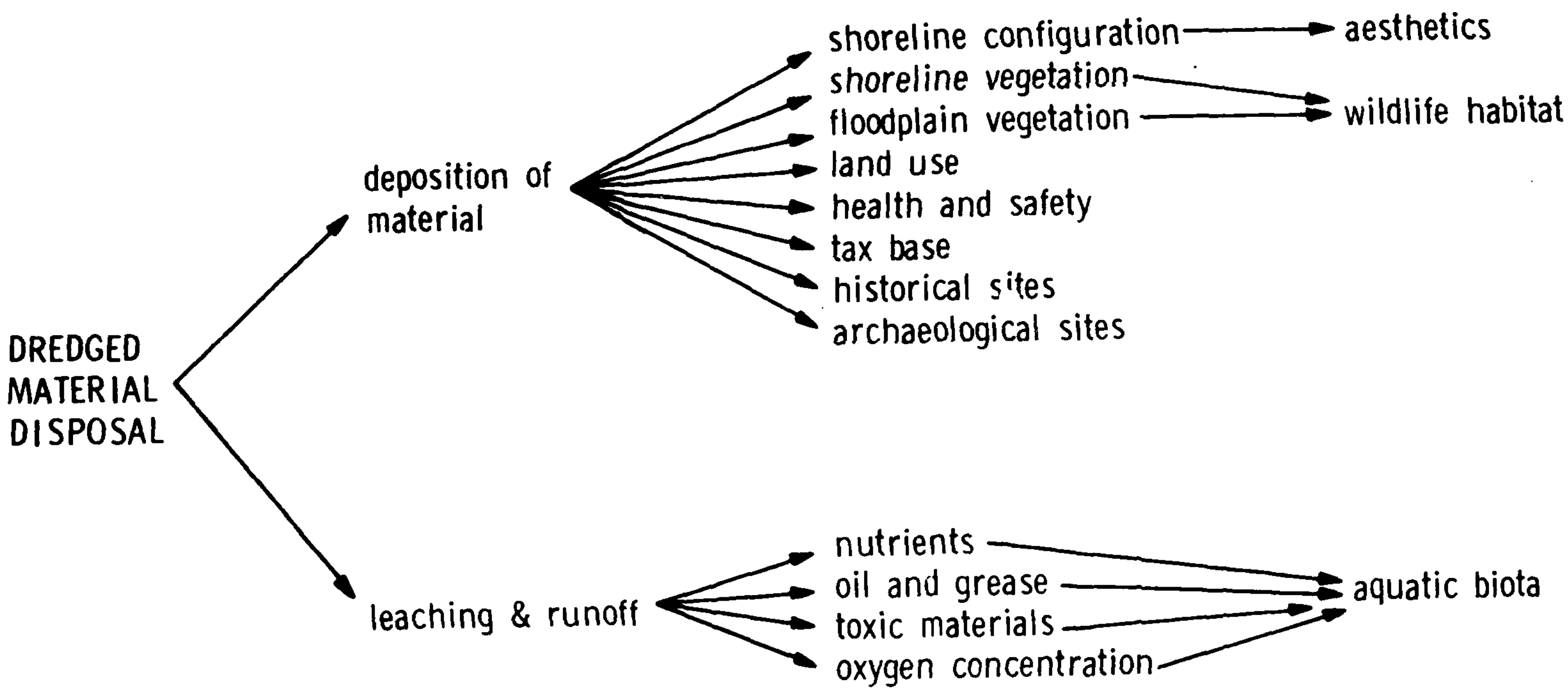


Fig. 4.3. Dredge Material Disposal Impacts.

4.93
Shoreline Vegetation, Floodplain Vegetation - Wildlife Habitat - The effect of the deposition of dredged material on the flora of the disposal sites depends upon the floral composition of the sites. Some sites have vegetative cover while others do not.

4.94
The major effect of deposition upon small woody plants, as well as most herbaceous plants, is the force and weight of the deposition process which can knock the plants down and subsequently cover them with material. In most instances, this type of action kills the plants. Some plant species have the ability to regenerate stems and grow through the deposited material to attain the original growth form of the plant.

4.95
Large woody plants such as trees, are affected in a different manner than smaller woody plants or herbaceous plants. The effect of deposition in an area that is presently inhabitated with trees is the possible killing of the trees by covering of the root systems. This covering is tolerated in different ways by different tree species. For example, Eastern Cottonwood (*Populus deltoides*) can tolerate a great deal of root system coverage, while Silver Maple (*Acer saccarinum*) cannot. Willows (*Salix*) and other wet-site shrub species may be eliminated when the impounded area is completely filled.

4.96
The deposition of dredged materials at the anticipated land disposal sites will not result in destruction of any environmentally valuable wetlands or marshes. Proposed lowland areas to be filled are presently unusable farm field swales and filling as planned should result in an improvement to the area without creating significant adverse environmental effects.

4.97
The destruction of habitat by deposition of dredged materials, though not extensive, will eliminate a portion of the habitat that would be used by the local fauna. The loss of the small woody and herbaceous plants will reduce cover and food sources that might be used by reptiles, amphibians, mammals and birds that nest on the ground. The loss of large trees from some disposal sites will reduce available den trees for mammals and nesting sites for some birds. Disposal of dredged materials at several locations will be accomplished with the intent to protect tree cover. Filled containment areas should achieve vegetative ground cover in a short period of time. Every effort will be made to fill the selected sites at the earliest possible time after its use commences. The flora and fauna of existing disposal areas are evidence that disposal sites will support future biota.

4.98
Land Use - Selected disposal sites are, for the most part, vacant Federal property in the vicinity of dredging sites. Use of these sites is not

expected to inhibit existing or potential uses of surrounding private lands. However, due to the physical limitations associated with existing Federal properties, increased use of private properties for dredged material disposal purposes will become necessary in the future.

4.99
Dredged materials from several project locations will be used for agricultural or commercial fill use. Because the actual fill areas are unknown in some cases, the precise impacts associated with this form of dredged material disposal cannot be determined. Disposal sites and uses will be subject to state and local approvals.

4.100
In the past, some project area dredged materials have been given to local farmers to fill low areas of their fields. Filled areas are known to have generally produced poorer than average corn yields during the first two or three years after filling. Information on the specific impacts of the previous deposition of dredged materials on agricultural crop land, however, is not available since no records were kept on the individual recipients or the amounts used for fill purposes.

4.101
Previous experience[4] indicates that disposal areas can be used for agriculture, industrial, and commercial use within a period of two to five years. Highly enriched or high organic-content materials spread thinly over agricultural lands would not be subject to this time limitation.

4.102
Disposal of dredged materials is not expected to produce any significant odors. Odor problems have not been encountered at any of the previous disposal sites in the project area. Should a problem arise, an environmentally compatible method of keeping the odor to a minimum will be developed and coordinated. Possible operational procedures to minimize odor emission include applications of chemical oxidents and/or covering with a layer of earth.

4.103
Since the quantities to be dredged in any one area usually are small, and dredging may be required only at intervals of two to five years or more, the complete filling of an area and its conversion to useful land usually will require many years. The disposal program will provide for complete filling of the used portions of an area as quickly as possible with the available dredge material.

4.104
Health and Safety - The transfer of polluted sediments to proposed disposal areas will not create any spray so that aerosol dispersal of pollutants will not be a problem.

4.105
Tax Base - The use of proposed sites for dredged material disposal purposes will not affect local tax bases.

4.106
Historical and Archeological Sites - Onsite archeological surveys indicated that there will be no adverse effects on archeological or historical sites as a result of proposed dredged material disposal. A determination has been made of the State Historic Preservation Officer that the proposed action will not impact on any sites now included on or eligible for listing in the National Register of Historic Places.

4.107
One potential adverse effect has been foreseen and resolved. In this instance the Chicago District has agreed that no dredged material will be disposed of at a site known to encroach upon an area underlain by archeological relics. More information on this site and other aspects of the overall archeological survey performed by Dr. David Overstreet of the Great Lakes Archeological Research Center for this report is contained in a report filed with the State Historical Society entitled, "Archeological Survey for the Fox River Navigation Project Disposal Sites." As previously stated, the specific details of the nature and location of archeological sites must be withheld from general publication in order to protect the sites from vandalism.

4.108
Potential project impact on historical and archeological resources is limited to future currently unspecified Corps of Engineers' dredged material disposal activities. The probability of archeological sites within possible future disposal areas is considered to be high because the riverine-lacustrine setting along the Fox and Wolf Rivers and the eastern and southern shores of Lake Winnebago have been demonstrated as optimal habitation sites for several prehistoric and historic populations. Future disposal operations beyond those presented herein cannot be stated with any degree of reliability, nor can any recommendations for mitigation of adverse effects be offered until an intensive archeological survey and evaluation of potential disposal sites is accomplished.

4.109
Future proposed disposal sites will be investigated for the presence of cultural resources and survey results will be coordinated with the State Historical Preservation Officer and the Midwest Archeological Center of the National Park Service prior to their final selection and use. Also, if any given proposed disposal activity is found to adversely impact on any significant cultural resource, the Corps of Engineers will either select a suitable alternative site or prepare a detailed mitigation plan for preservation of the threatened resource. In the event that historic or archeological properties listed in or eligible for listing in the National Register of Historic Places would be affected, the Chicago District will comply with established Advisory Council on Historic Preservation procedures for the protection of historic and cultural properties (36 CFR Part 800). If archeological remains are revealed by project dredging activities, operations will be suspended and the State Archeologist immediately notified.

select a suitable alternative site or prepare a detailed mitigation plan for preservation of the threatened resource. In the event that historic or archeological properties listed in or eligible for listing in the National Register of Historic Places would be affected, the Chicago District will comply with established Advisory Council on Historic Preservation procedures for the protection of historic and cultural properties (36 CFR Part 800). If archeological remains are revealed by project dredging activities, operations will be suspended and the State Archeologist immediately notified.

Leaching and Runoff

4.110
The impacts associated with leaching and runoff from dredged material disposal sites are identified in the major branch of the tree labeled "leaching and runoff" in Figure 4.3. The smaller branches on the right side of the tree are discussed below.

4.111
The earlier discussion in conjunction with impacts of material removal is generally applicable to the considerations associated with leaching and runoff. The lack of understanding of the factors influencing exchange of chemical parameters between sediments and water also applies to leaching processes. To the extent that materials are released from the particulates, leachates and runoff from the disposal sites may contain heavy metals, nutrients, oils and grease, and oxygen-demanding substances. A general discussion on the subject of leaching and runoff is provided in the following paragraphs.

4.112
Where dredged materials are to be deposited along a shore or bay, dikes will be constructed to control runoff and reduce seepage of materials into the river or lake. No permanent change in water quality is envisioned as a result of disposing of dredged materials in this manner.

4.113
Substances may be leached from materials even where dikes are employed to retain polluted solids. Clamshell dredging operations produce material which typically have a solids content of approximately 80-90 percent. Some water is therefore deposited on the disposal sites with the solids. Most of this water will be lost to the atmosphere by evaporation but the possibility of leaching and runoff from disposal sites, as well as from other land uses represents a potential source of water pollutants.

4.114
Although it is difficult to predict the magnitude of the exchange of materials considering the nature of toxic materials which are present in the sediments, potential toxicity problems are indicated. However, sediments underlying the proposed disposal sites are, for the most part, fairly impermeable. Slow movement, low permeability, high porosity, ion exchange, dilution, and normal chemical reactions should prevent any serious adverse impact on surface water or groundwater resources. A clay liner would virtually eliminate this impact but the use of such

a system is not authorized. In any event, disposal sites are generally not in an area in which the groundwater is susceptible to pollution the geologic substrate of the basin is such that chemicals from the anticipated dredged spoils will be unable to contaminate deep, heavily used aquifers. The general flow of the leachate is also toward the Fox River.

4.115
Diked construction or structural containment will control, but not eliminate loss of solids by erosion, runoff, and seepage through dikes. Suspended solids will be effectively contained behind dikes but release of minor amounts of absorbed chemicals may affect water quality.

4.116
Aquatic Biota - The biotic impacts resulting from nutrients, oils and grease, heavy metals, and oxygen concentrations which are generated by leaching and runoff may be expected to be similar in nature to the same effects generated by material removal. However, the effects from leaching and runoff should be more localized and much less environmentally significant.

LOCK OPERATION AND MAINTENANCE IMPACTS

4.117
The impacts associated with the operation and maintenance of the existing lock structures along the Lower Fox River are identified in the tree diagram presented as Figure 4.4. The individual branches of the tree are discussed below as represented by the underlined subheadings.

Lock Operation Impact

4.118
Flow - Suspended Solids, Sedimentation - Aquatic Biota - The operation of the lock structures causes localized hydraulic effects in the vicinity of the lock. Water flowing through the locks generates a venturii effect on the downstream side. This means that the velocity of the water is greatly reduced just after passing through the lock and some suspended solid material may be settled out of the water column. Several of the frequently dredged areas are immediately downstream of locks. This type of sedimentation is very minor and is experienced only near the locks. It is considered that this aspect of lock operation does not have any significant effect on the movements or habitats of aquatic biota.

4.119
Energy Consumption - The 17 locks of the Lower Fox River navigation system are all manually operated mechanically driven devices. Thus, no expenditures of electrical or other energy except human muscle power is required for their operation and energy requirements need not be considered.

4.120
Water Surface Elevation - The purpose of the locks is to permit the passage of navigation vessels by the dams. Since the locks are operated

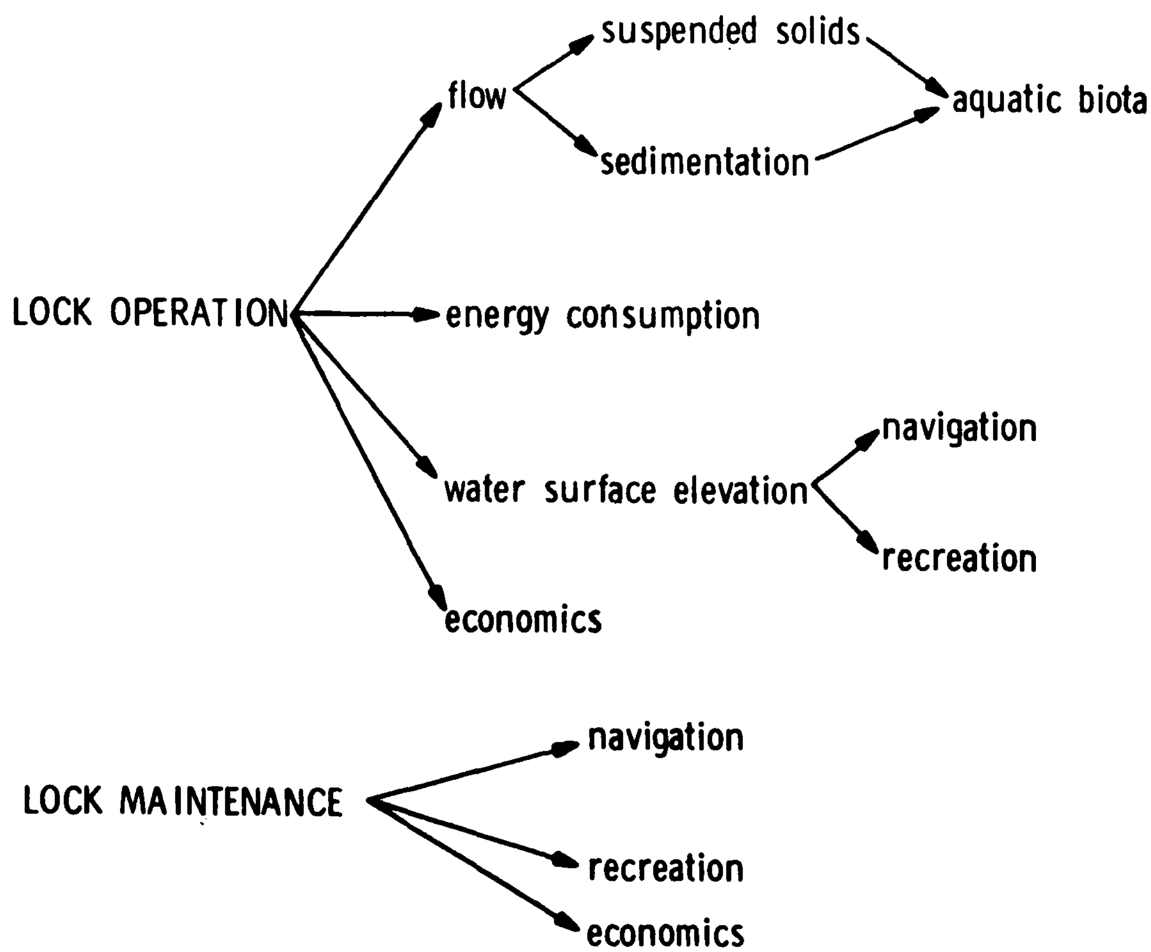


Fig. 4.4. Lock Operation and Maintenance Impacts

emptying device rather than continuous-flow device, their normal operation has an inconsequential effect on the surface elevations either above or below the locks or on the river flow past the locks. However, there can be flow-through if the locks leak badly. Water will seek this route to equalize head and thus reduce the pool level behind the lock and dam thereby increasing downstream flow. Fortunately, the locks are set off from the main river channel by canal banks, thus minimizing the rate of water loss through an open lock. This potential condition is unlikely since there are at least two sets of gates at each lock and the probability that both would be opened concurrently is quite low (in some areas there are multiple locks).

4.121
Navigation and Recreation - The operation of locks to pass vessels by the dams is essential to the maintenance of through recreational navigation on the Fox Waterway. Lock operation does not directly affect other forms of recreation besides boating. Maintenance and operation of the locks makes it possible for increasing numbers of the larger boats in recreational use on the Great Lakes to cruise to, and in many cases make prolonged stops on, the attractive boating waters of the Lake Winnebago Pool and the Wolf River.

4.122
Economics - In past times, the Fox River lock system provided a frequently used water passage from Green Bay to Lake Winnebago for the commercial transportation of goods and materials both into and out of the region. It is evident, though, that the original congressional intent of providing a waterway system for the movement of goods and materials into and out of the project area via water is ceased to be a valid reason for continuation of the navigation project. Present usage revolves almost entirely around recreational traffic.

4.123
The value of recreational navigation to the economy of project area communities is undoubtedly significant because boating and related recreational activities by individuals using project waters involve expenditures in the local communities affected.

4.124
An economic study of the Fox River project was undertaken in 1969. This study concluded that operation and maintenance of the overall Federal project was economically justified. A reanalysis of the economics of continued project operation and maintenance will be completed in Fiscal Year 1978. Among other items this analysis will specifically evaluate the economic feasibility of future channel maintenance and lock operation and maintenance required to support recreational boating. The results of this analysis will be summarized in a future addendum to this impact statement.

Lock Maintenance Impacts

4.125
The locks require preventative maintenance (sandblasting, painting, lubrication, etc.), repair, and occasional rebuilding of both the structures and component parts. None of these impacts are known to

produce significant adverse effects on the navigational activities. In all of these operations, some noise generation, energy consumption, and commitments of physical resources, money and labor are required. Because the lock components are simple, nonautomated, mechanical devices, only infrequent and minor impacts are experienced from failure of equipment.

4.126
Navigation and Recreation - The maintenance activities pertaining to the locks produce very minor effects except for the necessity of such activities to sustain navigation. Since the locks are not used on a year-round basis, navigation-disrupting maintenance can usually be done during the non-navigation periods.

4.127
Economics - Except for Menasha and Kaukauna 5th locks, the existing locks and dams are in generally fair to good condition. They should continue to give good service with normal maintenance. Menasha and Kaukauna 5th locks are in poor condition and should be replaced in the near future.

4.128
Menasha lock is considered the most important lock on the river since it is an essential part of the controlling works at the outlet of Lake Winnebago. This lock is the busiest of the Fox River locks with an average activity level of 2,608 lock operations and boat traffic level of 4,234 craft locked through during the last three seasons, 1973 to 1975.

4.129
Menasha lock was built in 1890 and is of composite construction. It has drywall stone masonry walls faced with plank attached to backing timbers anchored to the stone wall. The lock gates are timber. Although the walls have been repaired and replanked from time to time there still is evidence of considerable leakage. Despite nine major repair jobs undertaken in the last 50 years to reduce or stop the leakage, there is evidence of continued heavy leakage through the lock walls and through or around the cutoff walls, with frequent bulging of plank facing due to back pressure when the water level in lock is lowered.

4.130
Menasha lock was last extensively repaired in 1973-1974 at a cost of about $94,000. For the past 50 years the average cost of lock maintenance, emergency and major repairs has averaged over $8,000 per year. The condition of the lock remains such that as a safety precaution it is necessary to empty the lock at a slow rate to avoid possible displacement of plank wall facing or excessive scour around and through walls due to pressure from water that leaks into the walls and backfill when the lock is filled. Such slow operation is especially annoying to recreational boaters during the heavy summer weekend traffic. It has been necessary to suspend operations completely for several days during the navigation season to permit emergency repair work.

4.131
The continuing deterioration of the Menasha lock structure indicates that reconstruction rather than continuing partial and expensive repairs is warranted. Present plans call for the replacement of this lock within the next two years at an estimate cost of about $750,000 (1977 price levels).

4.132
Although the length and width of Menasha lock is somewhat greater than would be considered essential for the type of recreational traffic now using the river and expected in the future, it is proposed to maintain the currently prevailing usable lock width of 35 feet when this lock is reconstruc
ted. This will permit use of the waterway by construction and dredging equipment and barges of types generally in use on these waters, with resultant maximum benefits from the improvement. Most of the barges used by contractors working in this area are 30 to 34 feet in width and under 100 feet in length. That size is adequate for hauling the types of equipment needed for any prospective work in the area. The barges used by the Corps of Engineers for project maintenance operations are under 32 feet in width and 100 feet in length. The advantages of accessibility to the various channels and harbors by floating equipment outweigh any savings that could be made in the reconstruction of Menasha lock with a width less than the controlling 35 feet width at the other existing locks. There is no prospective demand for use of the waterway for the transport of materials with barges over 100 feet in length, and such length is adequate for the passage of prospective recreational boats even when several desire lockage at one time. Therefore, a saving in construction costs by reducing the usable length to about 105 feet is justified when new locks are required.

NAVIGATION IMPACTS

4.133
The operation and maintenance of project channels is a necessary prerequisite for the continued use of the river for navigation. Because of this very direct relationship, the impact of navigation is considered in this section in detail. These impacts are illustrated in Figure 4.5. Each branch of the tree diagram is discussed below as represented by the subheadings.

4.134
Recreation - As stated in other sections, the opportunity for recreational boating along the waterway serves as an incentive to other types of land-based recreation along the course of the river. Boating facilities such as marinas, docking and mooring facilities, and boat landings are developed at numerous points along the river. Major access routes to recreation facilities are often subjected to various types of commercial development. These forms of recreational development have associated effects on terrestrial and aquatic ecosystems which can be

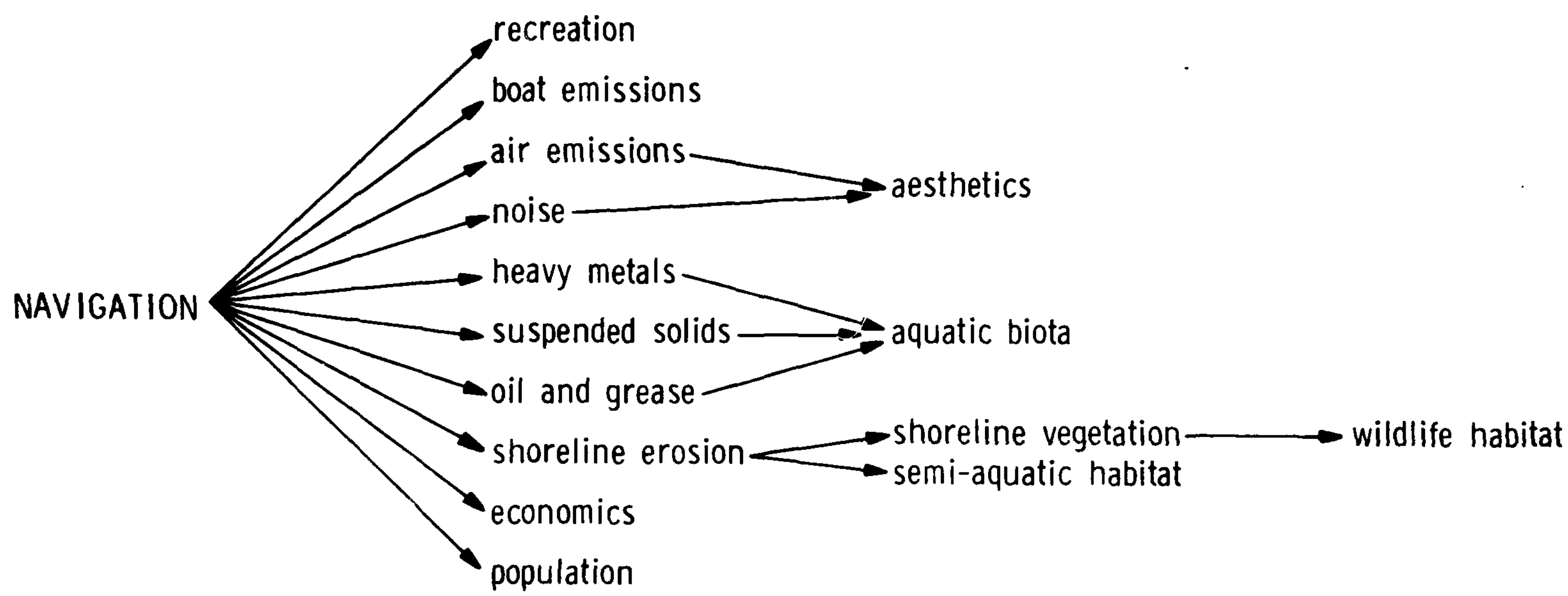


Fig. 4.5. Navigation Impacts.

significant when there are no zoning or land use controls. While the continued operation and maintenance of the Fox River, Wisconsin, Navigation Project provides for no increase over existing capacity for recreational navigation, the waterway is not presently used to full capacity. Traffic is expected to grow in the future. It is likely, therefore, that the incentive for secondary recreational land developments will be sustained. Review of the land use plans and policies of planning agencies along the waterway indicates that these agencies are equipped to regulate such development. The impact of this secondary development and its relationship to land use plans will be totally determined by the efforts of local planning agencies in controlling the type, amount and location of development.

4.135
Air Emissions - The fuel consumed by navigation is responsible for some air emissions. No measure of the exact quantities is available. Navigation sources probably make a small but detectable contribution to background levels of air pollutants along the waterway.

4.136
Noise - Recreational vessels generate noise while in operation. Exact noise levels vary considerably with power application and proximity to noise sensitive areas, such as residences, varies throughout the waterway. Most of the waterway is not adjacent to noise sensitive areas.

4.137
Aesthetics - There are many facets of navigation which could be aesthetically pleasing to some people while constituting an aesthetic impairment to others.

4.138
Heavy Metals, Suspended Solids, Oil and Grease - Aquatic Biota - Litter problems associated with recreational navigation uses may be significant. Current and projected increases in recreational boating will tend to increase suspension of sediments. Oils and grease residues and byproducts from combustion will enter the waterway, deteriorating the water quality to some degree. Heavy metals also may enter the waterway.

4.139
The motion of vessels along the waterway creates surface and subsurface turbulence which produces an increase in turbidity and suspended solids. Boating wakes erode unprotected shorelines, providing an additional source of solids to the waterway. Owing to the soft and unconsolidated nature of some of the bottom substrate, the passage of boats will resuspend silt-size particles which have been deposited.

4.140
The discharge of exhaust emissions from boats into the water can have negative effects upon water quality. The cumulative contribution of any heavy metals, suspended solids, and oil and grease can be expected to be a factor in the overall ambient levels of these constituents in the

waterway river. It is the nature of the emissions, rather than their quantity, that is of greatest concern regarding water pollution. While raw fuel, oil, and phenols are persistent or exotic pollutants, lead is a conservative one. Gasoline contains over 100 compounds, mainly hydrocarbons from C_6 to C_{10}, including straight chain and branched alkanes, cycloalkanes, and alkylbenzenes. These compounds, found in raw or manufactured fuels, are toxic to various aquatic organisms. Some compounds evaporate from the water surface and thus contribute to air pollution, others are soluble in water, and still others form oil slicks or settle to the bottom. Thin surface films of oil cause interference with the reaeration of water by stopping oxygen diffusion into the surface water and subsequently to deeper layers. Additionally, an oil film can interfere with the oxygen uptake by surface breathing organisms. Most of the waste oil discharged into the water accumulates in the surface layer. Little is known about the rate of degradation of hydrocarbons, although they are known to be degraded slowly by marine microorganisms. As with raw fuel, phenols are very resistant to microbial degradation and are transported over long distances. Concentrations exceeding 0.1 mg/l are hazardous to aquatic life (National Academy of Sciences, 1973). It is high ambient levels of this and other pollutant constituents in the waterway which would most affect the species composition and population size of aquatic biota.

4.141
Shoreline Erosion - Bank erosion has become a serious problem in several parts of the region. It is especially severe in Waupaca County but it occurs in many places along the Wolf River. In Winnebago County, bank erosion has been especially severe at the mouth of the Wolf River. Various reasons have been advanced for the increasing erosion in the region but the passage of recreational traffic through areas where shorelines are unprotected from wakes has been responsible for some erosion. Navigation traffic can cause great fluctuations in the inundation of shoreline areas. This washing action can result in the removal of substantial quantities of material.

4.142
Semi-aquatic Habitat, Shoreline Vegetation - Wildlife Habitat - In some areas, the shoreline and banks of the Fox Waterway do not support vegetation or semi-aquatic habitat. Although this condition is largely due to fluctuations in water surface elevation, the wakes from navigation traffic contribute to this problem. Prop-wash from large boats also tear up submergent vegetation in the channels and bays. Large horsepower motors seem to be increasing in popularity, thus the problem compounds.

4.143
Maintenance of a four-foot channel in the Wolf River encourages the use of this river by larger and more powerful vessels. Smaller draft, lightly powered boats, such as those typically used by fishermen, can usually navigate shallow waters over sandbars and, therefore, do not need the four-foot water depth produced by dredging. This is not true for the

larger boats, however. The larger boats often "push" water, creating large wakes that erode away the banks and vegetation. Therefore, maintenance of the four-foot channel to allow access by large boats is compounding the problem of erosion of banks and wetland.

4.144
The maintenance of the waterway from Lake Poygan to New London has increased boat traffic in this area. The influx of people and boating noise in this area can potentially impact wildlife species inhabiting floodplain forests. One mammal of concern is the bobcat (*Lynx r. rufus*). This species of changing status in Wisconsin[13] requires extensive forested areas and is generally quite wary of people, but insufficient data are available to assess the effect (if any) of increased boating traffic on this species in the Wolf River area.

4.145
Economics - In addition to the direct recreational value to the persons seeking recreation there are important economic benefits to the community providing boating, picnicking, and camping opportunities such as result from maintenance of the Fox River waterway. Recreational activities by individuals involve expenditures in the local community affected.

4.146
State and local interests have provided extensive facilities to serve recreational boating needs. In several instances, major expansions of these facilities are planned. In addition to serving as small craft harbors of refuge and bases for launching hundreds of trailer-hauled boats used for recreational boating and fishing in project waters, the project improvements at Fond du Lac, Calumet Harbor, Brothertown, and Stockbridge will provide the main access channels for further private marina developments as the recreational boating demands of the area increase. However, the continued maintenance of the navigation improvements will not materially alter the projected regional economic growth. The principal reason for this is that the existing navigation facilities and their contributions to historic economic growth are incorporated into the projections themselves. The projections are extensions into the future of historic trends in regional comparative advantages. Accordingly, the continued maintenance of the project will not stimulate growth above that which is projected. Rather the maintenance will remove a constraint to growth.

4.147
Population - It is not expected that continued maintenance will have any measurable effect on natural population growth rates or on any aspect of population structure. Any impact on the number of permanent residents in

the study area would result from changes in the level of economic activity induced by the project. As stated above, the economic projections are considered "with project" conditions.

DAM OPERATION

4.148
The impacts associated with the navigation dams of the Fox Project are identified in the tree diagram which is presented as Figure 4.6. The individual branches of the tree are discussed below as represented by the underlined subheadings.

General

4.149
Lake Winnebago is part of the Fox River Navigation Project and regulation of its stage is undertaken in the interest of navigation and is required in accordance with Federal laws and to protect the private rights of water-power and riparian interests.

4.150
The regulation of Lake Winnebago depends on forecasts of precipitation and on the amount of snow melt which can be anticipated in the late spring months. This is not an exact science but the object is to regulate the lake in anticipation of all probable increases in level which might exceed the upper limit. It is for this reason that the lake is lowered below the crest of the dams in the early spring in order that sufficient capacity in the lake basin will be provided to store large spring inflow from the drainage area of the lake. This must be done because the means of control to pass water into the Lower Fox River are not equal to the flows of water coming into the lake. Furthermore, if it were possible to pass the total inflows as they occur, serious damage downstream would most likely result.

4.151
Reports are received daily in the Chicago District Office on various gages in the Fox-Wolf River watershed to assist in the regulation of Lake Winnebago. During critical periods up-to-the-minute reports are obtained by telephone. Close contact is made with the U. S. National Weather Service to have the benefit of the most recent weather reports, including forecasts.

4.152
Just as extreme high and low levels have been experienced on Lake Michigan within the past few years, so have the conditions on Lake Winnebago been near both extremes. As recent as 1960, the third highest stage of record occurred on Lake Winnebago. In May of that year, the peak was 32 inches above the crest, or about 11 inches above the upper limit of regulation. Such an extreme is estimated to have an expectancy, on the average, of once in 33 years. The reason was due to exceptionally heavy precipitation over the watershed; the amounts exceeding the advance precipitation forecasts by the National Weather Service.

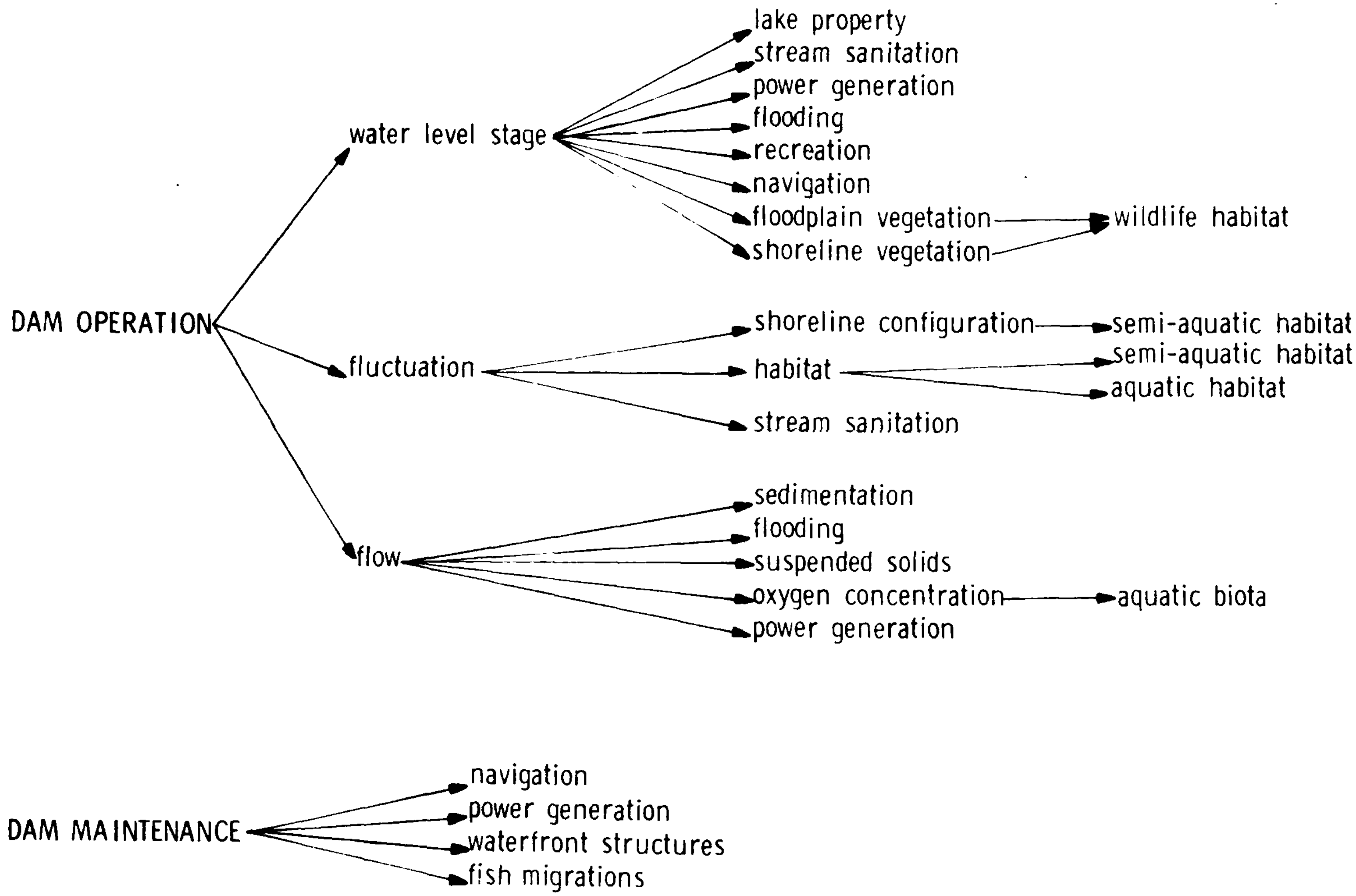


Fig. 4.6. Dam Operation and Maintenance Impacts

4.153
During some low water periods, the water supply to the lake is less than the loss by evaporation, plus the small amount needed to maintain navigation. Unless a certain amount of stored water is available to supply the deficiency, navigation on the Lower Fox River and Lake Winnebago is handicapped and the pools behind the dams on the Lower Fox River can become stagnant, thus creating unsanitary and obnoxious conditions, causing losses of fish life, and creating water supply problems for some industrial plants and communities.

4.154
There are two outlets from Lake Winnebago, one known as the Menasha Channel and the other as the Neenah Channel. The Menasha Channel has been improved by the United States for navigation purposes, the outlet being controlled by the Federal dam in the city of Menasha. A private dam in the city of Neenah controls the Neenah outlet. Both outlet channels converge into Little Lake Butte des Morts below the cities of Neenah and Menasha and are part of the Lower Fox River. The elevations of the spillways (crest height) of the Neenah and Menasha dams are 745.85 feet above mean sea level (MSL) and 745.94 feet (MSL), respectively.

4.155
The water level of Lake Winnebago, and consequently the levels of Lakes Butte des Morts, Winneconne, and Poygan are controlled by the Corps of Engineers under regulations that have been in effect since 1886 and were last modified in 1920. These limitations are established by law and are not administrative determinations by the Corps of Engineers.

4.156
The limits of regulation under existing laws, orders and permits are from 21-1/4 inches above the crest of Menasha dam to the crest level during the navigation season, plus an additional drawdown of 18 to 24 inches during the winter. The water level of the Lake Winnebago Pool is regulated in accordance within these limits to preserve the private rights to use the water not needed for navigation for power development and to reduce flood damages.

4.157
The storage available in the Lake Winnebago Pool normally is substantially filled during the months of high inflow, thus reducing flood flows of the Lower Fox River. This storage provides supplemental flow for navigation, water power, water supply and sanitation during the dry months of the year. The availability of the Lake Winnebago storage and its proper utilization by regulation of the outflow is of major importance to navigation and various other regional and local interests.

4.158
The principal interests affected by the regulation of Lake Winnebago are: recreational boaters, water power developments, municipal and industrial water users, riparian property owners, and fish and wildlife interests. Due to the limited tolerances (inches, not feet) of

operation, and because the rights of non-navigational interests are subservient to the prior rights of navigation, there are necessarily times when all interests cannot be satisfied. Also, the requirements of each of these interests frequently are at variance with those of the others. This creates a problem which must be resolved with the minimum of adverse effect on all interests concerned.

4.159
The regulation of Lake Winnebago cannot be changed without violating the rights of water power users and navigation interests. Any change in present flow regulation limits and procedures in order to more fully meet the desires of other interests is dependent upon Congressional authorization.

Neenah-Menasha Dam Operation Impacts

4.160
The Neenah-Menasha dam operation impacts are variable and depend to a large extent on the level of the water upstream (high or low water stage) and the stability of the water level (stable or fluctuating).

Neenah-Menasha Dam Operation - High Water Stage

4.161
Floodplain Vegetation, Shoreline Vegetation - Wildlife Habitat - The crest elevation of the Menasha dam is about 745.9 feet (MSL). The standard low water level at New London, approximately 75 miles upstream of this dam, is 748.1 feet. Thus, only 2.2 feet (26.4 inches) of drop exist between these upstream and downstream points. By controlling the flow of water past the Neenah and Menasha dams, the Corps of Engineers regulates the water level of the Lake Winnebago Pool for navigation, power generation purposes, and flood control. During the navigation season (May 1 to November 1) this level can be as high as 21-1/4 inches above crest and is usually controlled to maintain a level between 15 inches to 18 inches above crest. Such action increases the water levels throughout the Winnebago Pool but with no backwater effect above Fremont. When the water level is at or above the upper limits of regulation (21-1/4 inches), many adverse environmental changes occur, such as the inundation and destruction of marshes and loss of bottom materials, and an increased depth and surface area of the lakes and streams.

4.162
Water levels on Lake Winnebago are of primary importance in the ecology of both aquatic and shoreline vegetation. High water levels, particularly at or above the upper limits of regulation, are believed to be adversely affecting marsh and floodplain vegetation areas.

4.163
High water levels above the range which plants will tolerate is one way by which Winnebago Pool vegetation may be adversely affected. Extended periods of high water levels, whether within the upper limit of regulation or not, can also retard or eliminate the growth of aquatics by

reducing or excluding sunlight because rooted aquatics are apparently unable to store sufficient food reserves in these perennating organs to sustain growth of photosynthetic organs up to the light in the spring in turbid waters more than four feet deep.

4.164
Unless measures can be found to reduce turbidity, then it is imperative that from a vegetative management point of view that water levels be carefully held down in spring and early summer when green growth begins and develops from the bottom. On the other hand, storage operations at this time reduce downstream flooding and provide needed water to augment low flows in late summer.

4.165
Since the seasons of the year when high water levels are maintained are generally periods when the vegetation is growing and reproducing, the controlled high water levels will also foster growth of submergent and emergent aquatic vegetation in other areas where these species would not normally exist. In some areas it may also foster displacement of terrestrial biota by both the water and aquatic vegetation.

4.166
Annual high water at the time of the spring ice breakup is another way in which high water levels may contribute to vegetative losses. Ice frozen into the vegetation is lifted by the rising water levels and tears loose the roots of the vegetation producing a floating bog mat. With continuing high water and wave action this floating bog mat gradually breaks up and floats away or disintegrates. Once the vegetation is lost the soil beneath is quickly eroded by wave action and moves downstream, leaving the area deeper than it was before the vegetation was lost. This makes conditions unsuitable for revegetation of the area and increases the size of open water area.

4.167
Any action which decreases the flow of streams and increases the open-water areas of both streams and lakes generally promotes the displacement of desirable fish species, such as bass, pike and walleye by such undesirable species as freshwater drum, burbot and carp.

4.168
Under the existing project these impacts are anticipated to continue as they have since 1886 when the 21-1/4 inch above crest height level control point for the Menasha dam was originally authorized.

4.169
Flooding - Although the Neenah and Menasha dams have limited capability for routing flood flows, they were not originally designed for flood control. In the past, the Neenah and Menasha dams have been modified several times to provide more discharge capacity. Flood flows at these locations are regulated in such a manner as to minimize flood damages both above and below the dams to the greatest extent possible.

4.170
During the last 50 years there have been several floods causing the inflow to Lake Winnebago to exceed the safe outflow by several thousand cubic feet per second. In the absence of storage capacity in Lake Winnebago and controlled outflow these floods could have caused extensive damage along the Lower Fox River.

4.171
Controlled use of the storage volume available in the Lake Winnebago Pool also results in substantial reduction in flood damages to low lands surrounding the pool. The improvement of the Neenah and Menasha channels and the addition of sluiceways to the two dams has made it possible to lower the level of the lake to 18 to 24 inches below the crest of Menasha dam in advance of the expected annual spring flood periods. The storage volume thus gained is available to hold flood water during the flood period and thus reduce the upper limit reached by the lake as a result of the excess of inflow over outflow during the flood peak. The volume of storage available in the pool between the level of the crest of Menasha dam and a level 18 inches below the crest is equal to 123,942 day second feet, or 245,840 acre feet. This is equal to the volume available between about 4-1/2 and 21-1/4 inches above the crest. At the upper limit of regulation, one inch of depth is equal to about 7,600 day second feet or 15,100 acre feet, and increases the area flooded by the pool by about 293 acres. Assuming that at least one-half of the storage available in the pool to a level 18 inches below the crest might be lost if the sluices were not available and used to reduce the pool level, about 62,000 d.s.f. of storage would be lost which would require an additional eight inches of depth at the upper limit of regulation to compensate for the storage lost. With the increase in the upper level the pool would flood about 2,350 acres more of the low land.

4.172
Properly regulated, flooding in the project area will continue to be controlled except for those occasions when extreme meteorological conditions prevail and outflow at the dams cannot keep up with the inflow to the Winnebago Pool. Much of the present flood damages occurring adjacent to the lake is a result of encroachment within Federal flowage easements.

4.173
Navigation - From [illegible] standpoint, high water levels increase lake depths and [illegible] this produces larger and more usable recreational water [illegible] boaters of the area, making recreational navigation [illegible] attractive. However, the increased depths are not necessary [illegible] activity because draft requirements of the boats using [illegible] range from less than 2 feet to about 4 feet.

4.174
Since no commercial barge navigation exists, no direct commercial economic impacts either beneficial or adverse will result.

4.175
Industry - Industrial and municipal users of river water are unable to utilize the maximum flow of the river during floods. The maintenance of high water levels in Lake Winnebago following the heavy spring flows has the beneficial effect of assuring adequate water impoundment during the relatively dry summer months. This impounded water is essential to industry downstream of the Neenah-Menasha dams. It also provides incidental water quality benefits to the Lower Fox River region.

Neenah-Menasha Dam Operation - Low Water Stage

4.176
During the winter and early spring months the water levels in Lake Winnebago may be reduced to a minimum level of 18 inches below the crest of the Menasha dam. Present water level management calls for a gradual reduction in water levels from October or November through the latter part of February or the first part of March. Exact timing of this drawdown depends on weather conditions and the volume of inflow. This action is taken to provide storage capacity for the heavy spring runoff upstream. It decreases the water level throughout the Winnebago Pool, increases flow velocity in the Wolf River near its mouth, decreases depth of the lakes and streams upstream of the Neenah-Menasha dams, and decreases the surface area of these lakes and streams above the Neenah-Menasha Dams.

4.177
Lake Property - Winter drawdown reduces the volume of water in the Winnebago Pool and makes room for the expected heavy flows in the spring. Low pool levels in the spring increase the gradient and permit a faster inflow of water from streams emptying into the pool. This reduces the chances for backups and floods along these streams and resulting damage to adjacent residential developments and municipalities.

4.178
An added beneficial impact of the low water levels during winter is the reduction in the potential for formation of property-destroying shore ice during the winter freeze and particularly in late winter or early spring when wind-driven breakup ice can cause serious damage to both natural and man-made shoreline features. Low water provides some insurance against severe ice damage to natural shoreline features and properties (houses, docks, piers, etc.) along the lakeshores because when water levels are at their extreme low in the more shallow edge waters, the ice will be resting on the bottom. When the breakup occurs, this ice, because it is not floating, acts as a barrier against ice shoves. The ice builds up off shore rather than on the shore. In areas which have deeper contours, the drawdown may not be severe enough to lower ice levels to the bottom. Complete protection then does not exist, but if water levels are low, the damage will be less.

4.179
Floodplain Vegetation, Shoreline Vegetation - Habitat - Winter drawdown reduces the volume of water in the Winnebago Pool. This decreases the

chances for spring flooding and accompanying bog losses. Since the seasons of the year when low water levels are maintained are generally the seasons when vegetation is dormant, direct adverse effects upon the vegetation are minimal, and replacement of aquatic vegetation in the dewatered areas by terrestrial vegetation does not normally occur.

4.180
Decreasing the water-covered areas could, however, have serious adverse effects upon the early spring spawning fish if low water levels were maintained into the spawning season. To preclude this potential impact, the Corps of Engineers, by agreement with the Wisconsin Department of Natural Resources, presently controls flows at the Neenah-Menasha dams in a manner which raises water levels in Lake Winnebago to crest elevation by the first week of April. This action was requested by the Department in 1959 to secure higher water levels in early spring to benefit fish life and early commerical fishing navigation. This change of operation from previous years could also adversely affect the still-frozen vegetation resulting in its loosening and displacement, which has been observed.

4.181
The requirement of having the basin pool level at the crest of the dam by this time, shortly after the spring runoff occurs, has apparently caused greater loosening and displacement of some areas of floating bog than which occurred prior to the operational change due to the effect of rapidly using spring water levels lifting the still frozen vegetation from its rooted moorings. A modification of this policy should therefore be considered and the Department of Natural Resources has indicated a desire to study the effect of abandoning the earlier higher water level concept.

4.182
Industry - Winter drawdown provides an adequate flow of water through the winter months to the stream below when pool inflows are reduced. This gives the paper industries and the power plants water needed through the winter period. Flows are augmented in the downstream river, reducing the possibilities of fish kills during the critical winter period. The winter and early spring sluicing also is desirable as it gradually wears away the ice on the lower river and avoids quick ice break-ups and ice jams in the spring.

4.183
Recreation - Under low flow conditions, the regulation of water surface elevation affects recreation in two ways. Recreational boating is sustained by the provision of adequate channel depth. Water oriented recreation, such as fishing, which takes place on the shoreline is affected by the degree of variation in the location of the land-water interface.

4.184
The maintenance of project depths of proper dam operation at low-flow is a requisite for the continuance of current and projected levels of boating activities. Low water levels can make some permanent docks, marina slips, and launching lanes unusable. Low water levels can negate certain

benefits associated with past recreational investments, including some public facilities which were constructed with Federal Land and Water Conservation funds.

4.185
In addition to pleasure boating and sailing, the waters of Lake Winnebago are used extensively for fishing, water skiing, swimming, and canoeing, in addition to other water based activities. Hunting of water fowl is also a seasonal attractive activity. Although most of these activities would be possible without the Federal navigation improvement, the regulation of Lake Winnebago to maintain a fairly constant level during the summer season helps to maintain swimming beaches and full access and use to shoreline installations. Lake regulation also enhances combination boating and picnicking at the various public parks and scenic areas along the waterway. It is also estimated that about 10 percent of the regional camping use is in excess of the use that might be expected without the more favorable water levels and conditions resulting from the regulation of the lake level and the maintenance of the navigation project.

Neenah-Menasha Dam Operation - Fluctuating Water Levels

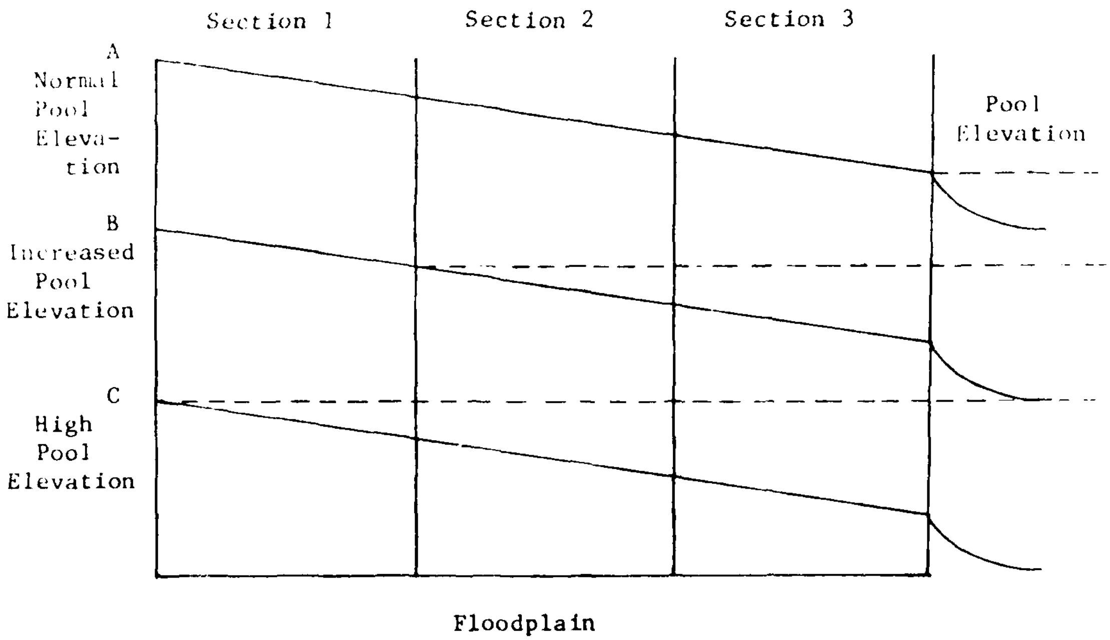
4.186
Shoreline Configuration - Semi-Aquatic Habitat - Regulation of the water elevation on Lake Winnebago has great effects on the amount and extent on shoreline and floodplain vegetation.

4.187
The greatest effect is generally found in the lower and middle segments of the pool, due to the gradually sloping floodplains. The rise and fall of water levels may cover or expose several hundred feet of potential shoreline. For example, areas that are normally dry and have mesic vegetation at normal pool level (Figure 4.7A, sections 1, 2, & 3) may be changed to a hydric habitat with a slight elevation of the water level (Figure 4.7B, section 2). Similarly, further increases in water elevation may render this situation to one of strictly an aquatic nature, leaving all flora that are capable of growth in shallow water eliminated and only those species which grow entirely submerged present (Figure 4.7C, sections 2 and 3).

4.188
As may be noted in Figure 4.7, the potential shoreline has several positions at which the water and shore interface may occur, depending upon the water level.

4.189
Fluctuating Water Levels - Aquatic and Semi-Aquatic Habitat - A glacial dam lake in its origin, the water level of Lake Winnebago is now controlled to a considerable degree at two artificial dams in Neenah-Menasha operated by the Corps. Although flows and water levels show considerable variation between years, the controlled water levels of the project area upstream of the Neenah-Menasha dam follow a yearly pattern of change due to human intervention. This pattern of regulation is accentuated or

Fig. 4.7. Comparison of Mesic, Hydric and Aquatic Habitats



Section 1 Mesic in A & B, Hydric in C
Section 2 Mesic in A Hydric B Aquatic in C
Section 3 Mesic in A Aquatic in B & C

dampened by the variations due to meteorological conditions (precipitation or draught) with extreme flood conditions in spring and/or draught in late summer. Natural water level fluctuations have become severely aggravated because of intensive farming and its accompanying drainage of wetlands.[6]

4.190
Deforestation and the construction of ditches for the benefit of agriculture has accelerated runoff and altered drainage patterns, increased the intensity and volume of recent floods, and altered the erosion/sediment characteristics of the natural stream system. These conditions make it more difficult to control water levels and lead to the destruction of aquatic and semi-aquatic habitats.

4.191
From historic times to the present there has been a gradual, yet persistent decline in the quantity and quality of the vegetation in the upriver lakes and marshes. These lakes include Lakes Butte des Morts, Winneconne and Poygan. At times the changes have been imperceptible and at other times they have been quite obvious, but it is known that they are occurring. For example, prior to the construction of the Neenah-Menasha dams, Lake Butte des Morts had such extensive wetlands that only canoe passage was possible, yet by 1914 there were 4,505 acres of open water,[8] and 8,857 acres in 1974.[2] This increase in open water has been at the expense of the natural emergent and submergent vegetation. Between 1916 and 1961 more than 6 square miles of emergent cover disappeared in Lake Butte des Morts alone.

4.192
Although there are no records available of the submergent vegetation originally present in the upriver lakes area there is a general unanimity amongst those who have a knowledge of the area that the submergents are decreasing. Turbidity and rough fish activities are the chief factors listed for this decline. It also seems that there is a strong possibility that the loss of submergents is closely associated with the loss of emergent cover. When large areas of emergent cover are lost it opens up the area formerly occupied by emergents to bottom erosion due to wave action. Waves churn this material into suspension and produce highly turbid water conditions which may have a deleterious effect on adjacent areas of submergent vegetation. This situation may be further compounded as greater and greater expanses of open water are exposed to wind and wave action.

4.193
While the cause or causes of marsh loss have been the subject of much speculation and some controversy, it appears likely that the construction of dams at Neenah-Menasha in the mid-1800's placed a stress on the marsh by raising the level of the water.[6]

4.194
When the Menasha dam was originally built in 1850 (prior to the date on which the U. S. acquired the facility), the low water level in Lake Winnebago increased approximately two feet, which caused water to back up

into Lakes Butte des Morts, Poygan, and Winneconne, and the Wolf River. This increased water depth is believed to have inundated large expanses of wetlands that previously existed within these bodies of water. The water depth became too great for some of the submergent and emergent vegetation, causing it to die off and decompose.[6]

4.195
While some attribute continuing area marsh losses to the initial pool level increase brought about by these dams, they have probably had less effect on marsh wetlands than is commonly supposed. There is strong evidence that marshes in the upriver lake region were firmly established long before the dams, and for many years afterward.[6]

4.196
Among other explanations which have been offered to explain marsh loss are the effects of boating, wind and wave action, pollution, rough fish activity, turbidity, and ice, which floats upward with rising waters in early spring, lifting and tearing loose the marsh which is frozen into it.[6] While it may well be that all of these factors are contributing to loss of marsh area, the relative importance of any single factor is unknown.

4.197
The ice explanation is really one of water level fluctuation. During winter drawdown standing water on the wetlands as well as within the root systems freezes. When the water levels rise again in the early spring before the ice has melted, the frozen mat-like systems also rise and are torn from their substrate. This creates floating mats of vegetation which are subject to wind and wave action. In time these floating mats break up and wash downstream.

4.198
Explanations based on water level fluctuation appear strong. It seems that the heavy forests, lush bluestem prairies and savannas, and extensive expanses of wetlands which existed in the area before disturbance by white men sufficiently buffered surface water and groundwater response to precipitation that the total range of fluctuation of water level in the upriver lakes and marshes was very small. The massive-scale cutting of forests, plowing of lands, and draining of wetlands would be expected to cause greater and more rapid water level changes--changes which would be disastrous to floating and semi-floating mats of plants which had been able to grow thus only because of comparatively stable water levels.[6]

4.199
The timing of the major breakup of the marsh is also more nearly supportive of "range of fluctuation" hypotheses than of the "raised lake level" hypothesis. It appears that if loss were attributable to a sudden change of level dating from the mid-1800's, the marsh loss would have been more sudden and dramatic, and little would have been left by the early years of the twentieth century.[6] But the marsh seems to have remained pretty well established until the 1920's. The episode of tree cutting, plowing, and wetland drainage was not fully under way until after the construction of the dams, and the process was proceeding at great pace well into this

century. In fact, wetlands are still being drained. Given a degree of lag between the time of land disturbance and the loss of marsh, the timing fits rather well into the "range of fluctuation" hypothesis. Of course, the fluctuations are governed to some extent by the dams, but the range they permit may well be greater than the range prior to extensive settlement of this area. This, coupled with the watershed changes described above, has led to higher water levels over longer periods of time on a more frequent basis than that which existed prior to original dam construction.

4.200
The aquatic plant species (both emergents and submergents) which inhabit Lakes Butte des Morts, Winneconne, and Poygan today are noted in Table 2.32. As was determined by Harriman,[9] the tolerance for water depth and bottom types is quite variable between species. Some rooted aquatics such as bushy pondweed (*Najas flexilis*) and American lotus (*Nelumbo lutea*) have a very narrow water depth tolerance range and are likely to be impacted greatly by fluctuating water levels.[7] Other species such as hardstem bulrush (*Scirpus acutus*), arrowhead (*Sagittaria rigida*), pickerel weed (*Pontederia cordata*), and reed grass (*Phragmites australis*) have the ability to tolerate relatively deep waters and withstand wave action.[7,9] Reed grass, however, is decreasing at the present time because of increasing water depths and detachment after freezing, high spring water levels and high winds. In some areas of Lake Butte des Morts floating vegetation mats covering several acres have been washed downstream. Floating vegetation mats are in many instances over deep waters and do not become rooted to the bottom.

4.201
The vegetation mat which is floating in many places is extremely susceptible to breaking up and disintegration. Floating bog is a very unstable condition in marshes of this part of the state. In the northern areas of the state, sphagnum bogs form around the edges of lakes and ponds and gradually grow outward forming a dense floating mat over the open water. This mat continues to increase in thickness and coverage. This is not the same process which forms the southern and central marshes. Vegetation in these marshes develops mostly under conditions of low water and mud flats during the growing season. The vegetation is firmly rooted in the bottom soils and no vegetation will be produced if water levels are deeper than the plants can tolerate. The mat of vegetation usually dies if water levels become excessive after it is established. However, if ice action in the spring of the year should tear the mat loose, it will then float up and may persist for long periods even though the water beneath the mat has become excessively deep. This presumes that the mat remains intact and is not washed downstream. This is an extremely unstable condition since there is constant danger from wind and wave action. Paradoxically, however, it is also the only condition under which vegetation can exist in the area when water levels become excessive.

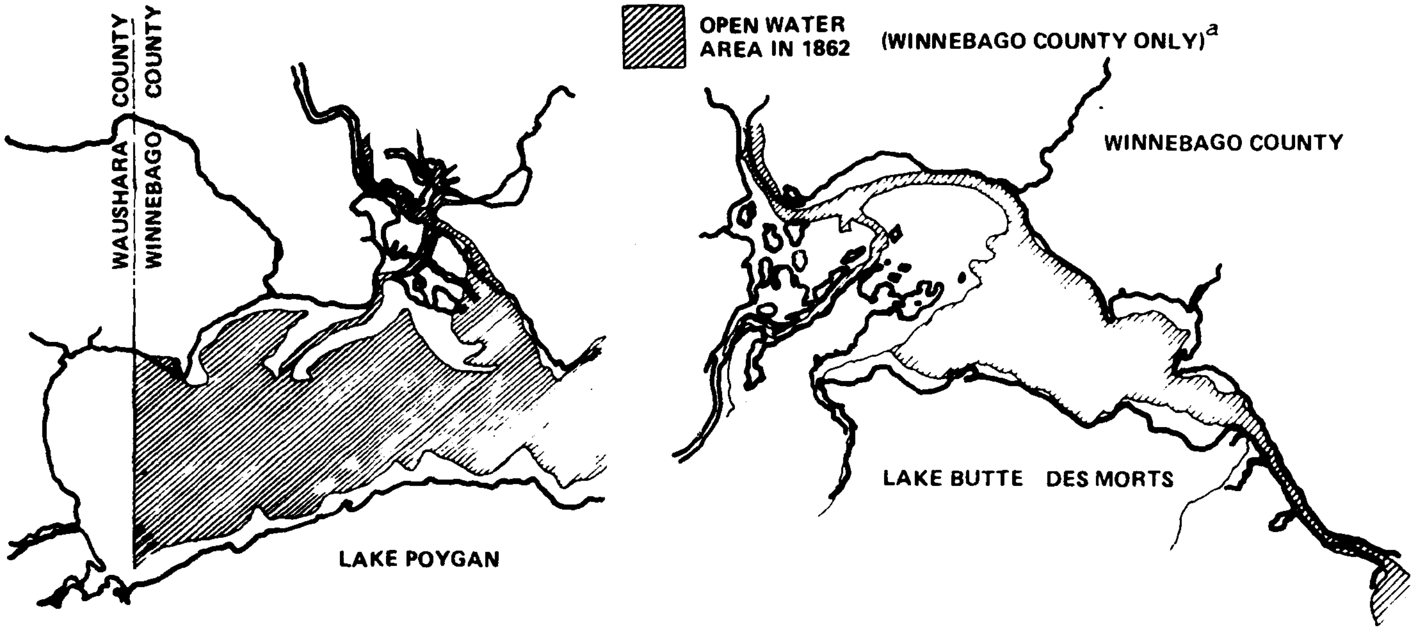
4.202
Floating and emergent vegetation were once predominant in the shallow lakes of this system and the water was normally clear. This is no longer true. The lakes and river channel are now open and consistently very turbid.

4.203
Historical records indicate that the open water surface area of Lakes Butte des Morts, Poygan, and Winneconne have increased since the U. S. assumed control of the waterway in 1872.[6,7] A historical perspective of those losses in Lakes Butte des Morts, Winneconne, and Poygan is shown in Figure 4.8. Undoubtedly the same story is true for Lake Winnebago and perhaps the lower reaches of the Wolf River. With this increased surface area and the fluctuation of water levels along the rapidly rising flood waters has come the destruction of considerable acreages of marsh and loss of habitat for many wildlife species.

4.204
This loss of vegetation has affected the fish fauna in these waters in several ways. Walleye and yellow perch are known to spawn in wetlands; therefore a reduction in these wetlands has caused a reduction in spawning habitat. The reduction in spawning habitat for the wetland spawning species becomes an increase in preferred open-water spawning habitat for species such as freshwater drum and carp. The Wisconsin Department of Natural Resources has had to institute a Rough Fish Removal Program to reduce these latter populations in order to increase the quality of sportfishing.

4.205
Loss of vegetation has also reduced the amount of food available, particularly since invertebrates require it. Since vegetation also provides refuge as well as food for the offspring of various fish species, these offspring are subject to higher levels of predation. All of these factors have probably led to undesirable changes in the fish fauna and may be gradually reducing the quality of recreational fishing within these waters, although no known reports have been issued that specifically prove these contentions.

4.206
The loss of marsh vegetation around lakes also decreases the available breeding and foraging habitat for many amphibians and reptiles.[10] Breeding habitat for many frog species along much of the shorelines of Lakes Butte des Morts, Poygan, and Winneconne has been eliminated. The green frog (*Rana clamitans*), bullfrog (*R. catesbeiana*), and American toad (*Bufo americanus*) all lay eggs on the surface of the water. The eggs of these species may not be as seriously affected by habitat loss as would eggs of the leopard frog (*R. pipiens*), which are generally deposited in globular masses in emergent vegetation. Any loss of breeding habitat, although seemingly insignificant, will add to the decline[11] in abundance of this species in Wisconsin.



[a] *The original 1862 map did not include the west portion of Lake Poygan within Waushara County.*

Fig. 4.8. Historic Perspective of Wetland Losses in Lakes Poygan and Butte des Morts 1862-1962. Redrawn from A. F. Linde, Wisconsin Dept. of Natural Resources, 1975.

4.207
With the exception of the central newt (*Notophthalmus viridescens louisianensis*) and the tiger salamander (*Ambystoma tigrinum*), all salamander species breeding in the lakes (see Table 2.34) are dependent upon marsh vegetation for egg attachment and larval development and consequently have probably declined in abundance in these lakes.[10]

4.208
Foraging areas for some reptiles decrease with the elimination of marsh vegetation. Young turtles forage in marsh areas, spending most of their time in dense stands of emergent vegetation. Forage species for such common snake species as the eastern garter snake (*Thamnophis sirtalis*) and northern water snake (*Natrix sipedon*) will also decrease with the loss of wetlands.

4.209
The State of Wisconsin and private individuals have riprapped some areas of Lakes Poygan and Butte des Morts with stone to prevent further losses of marsh vegetation. The stone riprap will provide more breeding and foraging habitat for mudpuppies (*Necturus maculosus*), increasing the abundance of these amphibians in riprapped areas. Clay dikes and riprapped areas may increase the available nest sites for many aquatic turtles.

4.210
No endangered amphibian or reptile species are known to inhabit the project area. Thus, the habitat losses mentioned above are not expected to eliminate any endangered amphibian or reptile species from the project area.

4.211
The loss of marsh vegetation may result in a local decline in muskrats but will have little impact on the status of the species in the project area. The least weasel (*Mustela nivalis*) is very uncommon[12] throughout Wisconsin and will probably be reduced in number in portions of the Wolf River-Lake Winnebago area with a decline in marsh habitat.

4.212
No other mammalian species of old fields, lowland and upland forests are expected to be adversely affected by the fluctuating water levels of the Wolf River-Lake Winnebago drainage basin.

4.213
The loss of wetlands in the Wolf River-Lake Winnebago area is the most serious threat to the avifauna of the project area. The loss of marshlands reduces habitat for nesting, foraging, and cover for many species of waterfowl and marsh songbirds (see Table 2.35).

4.214
Although no recent data[14] exist on breeding-bird densities for this area, some information is available for similar habitat in Rush Lake, a 3,000-acre lake in the southwest corner of Winnebago and adjacent Fond du Lac

Counties. With caution one can apply these data to the above mentioned lakes to gain some idea of the importance of marshes as nesting habitat for birds. Waterfowl species nesting at Rush Lake in 1972 and their estimated densities (pairs/100 acres) are: coot (6.7), blue-winged teal (0.8), ruddy duck (1.0), redhead (0.2), shoveler (0.03), mallard (0.2), and gadwall (0.03). The most abundant breeding aggregations were represented by the red-winged blackbirds (8.3) and yellow-headed blackbirds (30.0). Other species nesting at Rush Lake were the red-necked grebe, pied-billed grebe, black-crowned night heron, herring gull, Forster's tern, and black tern.

4.215
In the area, black tern and Forster's tern populations will suffer a reduction in available nesting habitat with a loss in reed grass (*Phragmites australis*) beds around the lakes, since their nests are built on floating vegetation mats. Although the Rush Lake marshlands are not identical to those of the project area, these data suggest that many species are probably present in the area and could be strongly impacted by a loss of marshes.

4.216
A reduction in marsh acreage has, in part, produced a decrease in the number of migrating waterfowl which use the area in fall for resting and foraging. The Wisconsin Department of Natural Resources reports that the estimated total number of waterfowl stopping in the Wolf River lakes has decreased from approximately 200,000 ten years ago to 2000 in 1974. The loss of habitat in the project area has also, in part, increased the number of waterfowl using the Horicon Wildlife Refuge as a stop-over area. The large number of waterfowl in the Horicon area has forced some birds into adjacent farmlands resulting in a greater loss of agricultural crops.[15]

4.217
The red-shouldered hawk, the only threatened species (State list) likely to breed in the project area, could be affected indirectly by a loss of marshlands. A loss of marsh could reduce habitat for garter snakes, ribbon snakes (*Thamnophis*), and water snakes (*Nitrix sipedon*), which are important food items of the red-shouldered hawk. The fluctuating water levels are not expected to directly affect any of the remaining threatened or endangered bird species, some of which are possible spring and fall transients.

4.218
<u>Stream Sanitation</u> - In order to maintain authorized project depths for navigation it is necessary at times to restrict the outflow from Lake Winnebago to such an extent that the lake becomes stagnant and the Lower Fox River becomes a series of still pools containing increasing concentrations of pollutants. Increased water flow from Lake Winnebago during the late summer and early fall would freshen that water body and alleviate polluted conditions downstream. The reduction of the unsanitary conditions which accompany low water can be achieved by a more uniform flow through Lake Winnebago and the Lower Fox River.

Impacts of Lower Fox River Dams (Excluding the Neenah and Menasha Dams)

4.219
As previously noted there are 11 dams downstream of the Neenah and Menasha dams. Unlike the Neenah and Menasha dams, which are the prime flow-control structures in the Lower Fox River, the other 11 dams are used almost exclusively for hydropower head, process water, navigation pool impoundment, and water quality improvement purposes. Except for periods drought or peak upstream runoff, the flow through the river and consequentially the river water levels are maintained fairly constant. Thus, only two water-level conditions (water flows) are commonly experienced, namely, high water stage and low water stage.

Lower Fox River Dams - High Water Stage

4.220
Navigation - Navigation in the Lower Fox River during high water stage can vary from risky to very dangerous; floating debris is in abundance, currents and turbulence are high, and changes of running aground on newly submerged areas are increased. Since these high water periods usually occur in spring prior to the opening of the boating season, channel markers, which are removed at the end of the previous boating season, have generally not been replaced. The absence of these channel markers signifies that navigation is not to be attempted. Thus, boating seldom occurs in winter because of icing nor in early spring because of high water stage.

4.221
Flooding - The most critical structures for dam operation are the Neenah-Menasha dams. All government dams on the Lower Fox River have been rebuilt to safely discharge the maximum estimated flow resulting from a discharge of 16,000 cfs at Neenah and Menasha, plus the industrial discharge from hydropower and process water and the probable maximum local runoff below the lake. None of the downstream project dams is a flood control structure as such, and the total effect of these dams on floods is negligible.

4.222
Flooding does not seem to be a problem below Neenah-Menasha as downstream dams can handle the full capacity flow from the Neenah-Menasha dams.[5]

4.223
Although flooding is not generally a problem along the lower reaches of the Fox River, it does occur occasionally in Little Lake Butte des Morts and in the industrial areas along the Neenah Channel at extreme high flows. At normal high flows, flooding in these areas is not a problem.

Lower Fox River Dams - Low Water Stage

4.224
During periods of severe drought, regulation of the Menasha dam is critical in maintaining flow through the Lower Fox River and assuring impoundments behind each of the downstream dams for navigation, hydropower, process water and water-quality control. These impoundments, however,

tend to stagnate, become highly enriched, and highly productive of algae and other nuisance growths. As a consequence, dissolved oxygen levels become severely depressed and biological activity becomes limited to those pollution tolerant life forms which are generally considered to be undesirable. Although additional water release from upstream would alleviate these undesirable conditions, regulations and other interests prohibit such activities except in extreme situations. For navigation purposes a minimum flow of 1,000 cfs as measured at the Rapide Croche dam is considered adequate. Excess flows are considered to be the vested water rights of the Neenah-Menasha Water Power Company and are, therefore, beyond the Corps of Engineers' authority to unilaterally produce by opening gates in the control dam (Menasha). At extreme low flows power generation may be curtailed if release of upstream water is not possible or navigation flow cannot be maintained. Thus, the priorities under low flow conditions require satisfaction of navigation requirements first, maintenance of hydro capacity second,[16] and riparian rights third.

Flow

4.225
General - One beneficial impact of high stage and flows is the increased capacity for power generation. Other benefits are that dissolved oxygen concentrations in the river are increased, while sedimentation rates in channels are reduced and scouring of some accumulated sediments occurs. However, turbidity is increased.

4.226
During low stage and normal flow conditions on the Lower Fox River, relatively little turbulence occurs at some locations on the river and sedimentation rates are increased. The next large spring flow, however, generally removes the sediment accumulations. But this action does not occur in backwater areas such as those found upstream and downstream of the locks. Thus, periodic dredging is required in the Lower Fox River to assure adequate depths for the craft using the lock system.

4.227
Power Generation - Fox River flow characteristics are modified by impoundments and power plants. Water is stored at times of peak runoff to be discharged later when flows would normally be minimal. The purpose of this activity is to augment natural streamflows to make hydro-power plants more efficient. This tends to minimize normal seasonal variations in streamflow. There also may be daily discharge peaks as power companies meet their peak electrical loads.

4.228
Oxygen Concentration - It has already been explained that the establishment of navigation pools reduced stream velocities. Another obvious direct result was an increase in average river depth. The rate of atmospheric reaeration is reduced because of both these factors.

4.229
Turbulence at the water surface-atmosphere interface would increase the rate of oxygen transfer from the atmosphere into solution. The turbulence is related to velocity, so that a decrease in velocities would produce less turbulent conditions.

4.230
The total quantity of oxygen which would be transferred increases as the surface area available for the mass transfer operation increases. The D.O. in the river would be related to the surface area to pool volume ratio. Pools with large volumes, i.e., deep pools, have a small surface area/volume ratio so that oxygen concentrations will be low. As pool elevations increase, the surface area/volume ratio generally decreases, hence dam operation may influence dissolved oxygen values in pools. It should be recognized that many other factors are involved in the oxygen economy of the Fox River. These factors were identified previously in the discussion of water quality (Section 2).

4.231
It should be noted that under some conditions improvements in dissolved oxygen are realized downstream from dams. The turbulence associated with water passage over the dam or through associated power turbines aerate the flow increasing the dissolved oxygen level. However, under drought conditions practically all flow passes through the hydropower turbines, and very little, if any, water flows through the gates or over spillways. Thus the dam aeration which may occur at moderate flow rates may be totally absent at very low flow rates.

4.232
The general use of the river for disposal of waste treatment plant effluents creates a demand that the low water flow of the river be kept as high and uniform as practical, principally by the most effective use of the storage capacity available in Lake Winnebago. Maintenance of this flow at the highest practical level is also generally desirable for efficient development of water power, except that there is some inclination on the part of parties using water for power to reduce the flow on weekends and other non-work days to conserve the water for later power peaks. This is likely to create a temporary stagnant condition in the downstream pools and is undesirable from a sanitary standpoint. Such temporary reductions in flow also are undesirable for their effect on maintenance of water levels for navigation in pools that have little storage capacity and hence are affected immediately by flow reductions.

4.233
Aquatic Biota - The most direct and most noticeable effect of dam operation on dissolved oxygen is the substantial reaeration which occurs, sometimes over large distances in the reach downstream of the dam. A corresponding improvement in habitat conditions for aquatic biota, however, is not realized in these reaches. Despite the dissolved oxygen enhancement, the pollution loading on the stream remains the primary limiting factor on aquatic organisms in the Lower Fox River.

DAM MAINTENANCE IMPACTS

4.234
The physical structures and the mechanical and electrical components of the dams require preventative maintenance (sandblasting, painting, concrete repair, etc.). This work is performed during times when access to the structures is convenient and safe (generally low-water periods). During such times, the interference of the repair work with normal dam operation is minimal. No aspect of the dam repair or maintenance is known to produce pollution or to adversely affect the natural or human community. In all of these operations, some noise generation, energy consumption and commitments of physical resources, money and labor are required.

4.235
As noted previously, the maintenance of the Fox River project, in particular the regulation of the storage in and discharge from Lake Winnebago, has a major impact on navigation, water power development, flood control, water supply and sewage treatment, and other water uses. Continued maintenance of the dams on the Lower Fox River is essential in sustaining these benefits.

4.236
Preventative maintenance is necessary to protect the structural integrity of project dams. Failure at any one dam would tend to increase the danger at all downstream structures. Any major failure probably also would result in the loss of all power production at one or more dams. Such power losses might continue for several months while repairs were made, and would be critical for some of the major industries and utilities using water power. Continued maintenance of the dams on the Lower Fox River is also necessary to protect the structural integrity of waterfront structures through the several cities and major industrial developments along the river. Major buildings and bridges have been designed in relation to present pools and many foundations and river front walls would be endangered by major changes in pool or ground water levels and by uncontrolled currents through the channel over the natural rapids formations.

4.237
Water Power Benefits - The Fox River navigation improvement has had, and still has, a major economic effect on the economic and industrial development of the whole Fox River valley. The conditions favorable to water power development resulting from, or greatly improved by, the Federal construction and maintenance of dams to maintain slack water pools to serve navigation have been a principal factor in the intensive urban development along the Lower Fox River and the west shore of Lake Winnebago.

4.238
It has been noted previously that when the United States purchased the navigation improvements along the Fox River in 1872, the right to use for water power all surplus water not needed for navigation was reserved by

all the private owners of power developments and water rights. At that time the developed water power and the water lots pertaining thereto were estimated by the appraisers as worth $140,000, while the appraised value and amount paid for the navigation improvements was $145,000. The agreement permitting the use of surplus water for power development did not guarantee that structures needed to maintain pool levels necessary for power development would be maintained or replaced at the expiration of their useful life.

4.239
Industries of the area have become less dependent on water power and the transportation of coal on the river since the introduction of natural gas to the area about 15 years ago and the construction of large thermal electric plants on the west shore of Lake Michigan making it feasible to transmit low cost electric energy to this area. Some of the older and less efficient electric generating plants have been abandoned or are held in standby condition to serve in an emergency. However, the water rights are retained by all the principal owners and in many cases the water covered by the rights is used in processing of manufactured products. The most recent hydro-electric power installation is that made in 1948 by the Kaukauna Electric and Water Department at the government dam at Little Chute with an installed capacity of 3,300 kilowatts at a head of 13 feet.

4.240
Fish Migration - The prime environmental disadvantage of dam maintenance is the continued presence of the dams themselves. The presence of the locks and dams has resulted in a blockage of normal migration movements of fish The long-term effect of the existence of the locks and dams has not yet been determined. However, there seems to be a sustained production of most fish species affected. Even though the locks and dams interfere with normal fish migrations, some fish are able to negotiate the locks during routine locking procedures up the Lower Fox River, through Lake Winnebago, to spawning on the Wolf River. These Wolf River spawning sites represent one of the few prime spawning grounds left in the Lake Michigan drainage basin. It should be noted, however, that in all likelihood the stretch of river between mile 23 to 33 must have acted as a natural barrier to fish migration up the Lower Fox River from Green Bay and Lake Michigan to the Wolf River due to the gradient. Currently, the polluted condition of the Lower Fox River is believed to be the primary factor limiting fish migration at the present time but the barrier effect of the existing lock and dam system is expected to become the limiting factor as water quality conditions improve.

REMEDIAL, PROTECTIVE, AND MITIGATIVE MEASURES

4.241
Some of the impacts associated with past operation and maintenance activities of the Fox River, Wisconsin Navigation System have been minimized. Remedial, protective and mitigative measures are discussed below

with respect to each of the various project elements. Additional operational management alternatives are still under investigation and consideration. They are discussed in detail in Sections 6 and 9.

Dredging

4.242
Material Removal - The impacts resulting from the removal of dredged materials from the channels are difficult to mitigate. Thus, the temporary increase of turbidity, destruction of bottom fauna, and exchange of chemicals between the sediments and the water column will inevitably occur. Some energy consumption, monetary costs and labor will also be required. Noise generation and air pollution created by the engines of the dredging equipment can be reduced by mechanical improvements to the equipment but neither of these impacts is presently considered to be severe enough to justify the cost of the required modifications or equipment replacement.

4.243
Research - The detailed effects of dredging activities on the aquatic environment are not known at this time. There are a multitude of factors which can, together or singularly, modify the effects of dredging. Within the scientific community there are differences of opinion regarding the effects of dredging. Research is now being performed in this field to enable a more exacting assessment of the impacts.

4.244
Testing and research into the relationship of levels of turbidity and other water quality parameters on aquatic organisms as they relate to dredging activities is being undertaken by the U. S. Army Waterways Experiment Station (WES). Upon completion of these and other related studies, the potential effects of dredging on aquatic organisms will be better known. As the evaluations of data compiled in this research effort become available, it may also be possible to identify the most environmentally compatible dredging equipment, policies, and procedures.

4.245
Channel Dimensions - Dredging is to take place entirely within existing channels. Given the current usuage of the navigation channel system, there is little, if any, allowed flexibility for reduction of channel size and consequently the amount of dredging required.

4.246
Channel Depths - Prior to the performance of any dredging, soundings are taken to determine dredging requirements. Only those portions of project channels which fail to meet navigation requirements and which have a depth of less than that authorized will be scheduled for dredging.

4.247
Dredging Requirements - Maintenance dredging is intended to provide for the reasonable needs of navigational traffic and be economically justified. While additional study on optimum depths to be dredged is needed periodic maintenance dredging and disposal would still be required to maintain less than authorized channel depths.

4.248
Dredge Plant - To date, the Chicago District has used clamshell dredging to maintain navigable channels throughout the Fox waterway system. However, if the area to be dredged is relatively near a project disposal site, the use of a hydraulic type dredge with a pipeline to the point of disposal is possible. In order to maximize the Corps of Engineers flexibility in responding to continuing dredge material disposal requirements for the project, the Chicago District intends to investigate the addition of a hydraulic pipeline dredge to the dredge plant for the Fox Project.

4.249
Wolf River - In fulfilling Federal maintenance responsibility on the Wolf, the Corps of Engineers is seeking a greater balance between recreational boating needs and fish and wildlife interests in order to insure maximum benefits to all users of the river. In order to accomplish this objective, the Chicago District will coordinate all future proposed dredging and snagging sites with the Wisconsin Department of Natural Resources. Dredging and snagging operations will be limited to only those reaches of the Wolf River which are approved for maintenance after consultation with the State.

4.250
Scheduling - The proposed action will be coordinated and scheduled so that it will be as environmentally compatible as possible within overall operational limitations. Every attempt will be made to avoid dredging during critical times of environmental stress such as fish spawning runs and periods of critical low dissolved oxygen content of project waters. As other environmental concerns become identifiable they will also be included in the scheduling process.

4.251
Spills - Special care is routinely taken to avoid spills of oils, fuels, and other pollutants during the dredging process in order to minimize the adverse impact of the project. When scows are used to transport very loose, soft dredgings the scow doors are packed with burlap bags.

4.252
Monitoring - Monitoring has not been done to determine the impact of dredging on water quality in the project area. A monitoring program is proposed to be set up in conjunction with actual dredging operations at selected locations to more precisely determine dredging effects on water quality. Monitoring at these locations will be conducted prior to, during, and after dredging operations to detect any potential undesirable effects such as dangerous buildup of toxic levels and excessive decrease in dissolved oxygen levels. Prior to initiation of the program, a specific monitoring plan will be coordinated with appropriate agencies such as the Wisconsin Department of Natural Resources.

Dredged Material Disposal

4.253
Sediment Samples - Representative bottom sediment samples were collected throughout the portions of the project area requiring maintenance dredging for the purposes of determining the physical and chemical characteristics of the materials to be dredged and suitable means of disposal.

4.254
The analysis performed measured the concentration of the several toxic elements in the dry material. While these tests do not determine quantities that may be eluted, they do set upper limits for the quantities. Since disposal is to be on dry land with essentially unknown chemical reactions and unknown release, the type of analyses used are conservative.

4.255
Also tests to determine the presence of materials which might cause odors were made. These include organic carbon content, as well as sulfate and organic nitrogen content. Oil and grease could be deleterious to waters and lands that receive the runoff waters from the sediment deposits. Therefore, tests to determine the presence of these materials were also made.

4.256
Particle size analysis determines the degree of turbidity to be expected, as well as the physical suitability of the materials for many beneficial purposes. A high fraction of small particle size material (clay) indicates high turbidity, as well as poor water drainage from the deposited material. Such material would dry and aerate slowly, making these materials detrimental to agricultural productivity for 2-5 years if deposited in thick layers and generally unsuitable as construction fill.

4.257
Finally, a number of tests to indicate the general suitability of the material for agricultural use were performed. These tests identify the available mineral levels, nutrient levels, and organic matter content, all of which are generally beneficial. Also indicated is the total salt content, which could be deleterious in agricultural soils.

4.258
Disposal Site Location and Design - The adverse effects of dredged material disposal have been mitigated considerably by judicious selection of disposal sites and containment of polluted dredge material. Site selection criteria were established for the purpose of reducing adverse effects to the natural environment, human utility, groundwater quality, and valuable historic sites or artifacts. Dikes will be built so as to prevent erosion and movement of deposited materials, as well as to confine and control runoff water. The recommended disposal plan has been coordinated with, and approved by, Federal and State environmental agencies.

4.259
Dikes will be protected against erosion by seeding or the use of stone riprap. Stone riprap will be used in those instances where diked construction might be subject to possible flooding during high river flows. Riprap will serve to provide a suitable habitat for a number of animal organisms.

4.260
Post-treatment of the disposal site to reduce the period of time that exposed, unvegetated dredged material piles are visible is possible. This can be accomplished by occasionally turning over the material to promote weathering and/or by seeding the deposits. Such techniques, however, have the disadvantage of increasing the area impacted and the cost and time allocations involved.

4.261
In the past, most dredged material disposal sites have been allowed to revegetate naturally. The vegetation of such dredged spoils were analyzed at Wolf River (Boom Cut), Menasha Channel, and below the Kaukauna 5th Lock, Little Kaukauna lock and the Little Chute-Combined Locks site. The plant species inhabiting these sites represent typical early successional species of floodplain and riparian communities. On the basis of vegetative analyses of known dredge disposal sites, new sites would be expected to support many of the same successional species.

4.262
For reasons of the above, seeding of dredged material deposits is not contemplated by the proposed action. However, should a situation develop where it becomes necessary to mitigate a serious erosional problem or enhance the natural recolonization process, the Chicago District will undertake a revegetation program appropriate for the area involved.

Dam Operations

4.263
Under existing laws, orders, rules and permits, the present limits for regulation of Lake Winnebago water levels are from 21-1/4 inches above the crest of the Menasha Dam down to the crest during the navigation season. During the closed navigation season a drop to 18 inches below the crest is allowed. These regulations were issued 15 October 1920 and are still in effect. The 1920 regulations were a modification of the so-called Marshall Order issued 9 October 1886 and made no changes in the upper limit of regulation originally established by the earlier regulations. The Corps of Engineers Fox River Regulation No. 13 still prohibits drawing the water level below the crest at any time except under special orders of the Fox River Project Office or during the closed season for navigation. A further closed-season lowering of the water level by six inches (from 18 inches to 24 inches) in case of anticipated exceptional spring floods may be authorized, but the impounded water is temporarily regulated so that the water level reaches the dam crest during the first week of April, as requested by the Wisconsin Department of Natural Resources.

4.264
The Rivers and Harbors Act of 1894, which contains rules and regulations for navigation on the Fox River, includes the regulation that no pool of the Fox River shall be lowered below the crest of its retaining dam. This regulation defines the lower dividing line between the rights of navigation and those of water power. Under present regulations all dams downstream of the Neenah and Menasha dams are controlled to assure pool levels above the crest. Flashboards have been authorized for many of the dams by the water power users during low flows. The table below shows the pool levels maintained by the existing operating regulations.

Dam	Minimum Pool Level	Maximum Pool Level
Appleton (upper)	6" above crest	12" above crest
Appleton (middle)	Private dam	Private dam
Appleton (lower)	6" above crest	12" above crest
Cedars	6" above crest	12" above crest
Little Chute	6" above crest	12" above crest
Combined Locks	18" above crest (Private dam)	24" above crest (Private dam)
Kaukauna (upper)	6" above crest	12" above crest
Kaukauna (lower)	Private dam	Private dam
Rapide Croche	30" above crest	36" above crest
Little Kaukauna (Little Rapids)	15" above crest	24" above crest
De Pere	6" above crest	18" above crest

*Maintained during the navigation season only.

4.265
The existing laws and orders pertaining to operation of the Menasha dam in conjunction with the precipitation and weather patterns upstream determine the flow through the Lower Fox River. Since present procedures are predicated on obtaining the best balance between varying water-use interests within these laws while attempting to insure navigation and to predict upstream weather, no meaningful alternative for the present operation appears to be feasible. Thus, present plans must be continued and will preserve the existing conditions downstream. The impacts associated with high flows downstream of the Menasha dam cannot be mitigated by alternative dam operating procedures because upstream flood flows are generally larger than the existing pool storage of the Winnebago Pool. The remedial measure of lowering the nonflood-period water levels of the Winnebago Pool is discussed in detail in Section 6 (Alternatives) of this statement. No other remedial, protective or mitigative measures for present dam operating procedures are known to exist.

Lock Operation

4.266
Under the existing laws which require a navigation system on the Lower Fox River, no alternative to the present procedures for the operation of the locks are known. Any attempt to reduce the hours of operation of the locks and thus reduce cost would result in restricting the use of the existing system to only one way passage per day because of the total time necessary for transit through the locks on a round trip basis (approximately 8 hours for a round trip).

Lock and Dam Maintenance

4.267
No alternatives to the present lock and dam maintenance procedures are known which will assure the continued safe and reliable operation of these facilities.

Navigation

4.268
Due to the small volume of traffic through the navigation system of the Lower Fox River, no significant impacts of navigation on this section of the system have been found. Therefore, no meaningful improvements of navigational impacts in this section of the project are known to exist. Navigational impacts due to boat wakes in the Wolf River section of the river have been observed. The effect of these wakes is increased erosion and undercutting of the shoreline. Boat wakes appear to be a combined function of both boat design and power. Thus, high speed is not always responsible for increased wake. Partial relief from damaging wakes caused by vessels could be achieved by the strict enforcement of the Wisconsin Boat Safety and Registration Act of 1959. No other remedial action for these effects are known, short of limiting travel in the streams or initiating an extensive program of shoreline protection by the addition of riprap to the riverbanks. This modification, however, could prove to be environmentally more adverse than the present wake action.

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SECTION 5

PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

5.01
Virtually all of the adverse effects identified in the preceding section which are attributable to channel maintenance and many of the adverse effects associated with dredged material disposal and dam and lock operation are unavoidable. Certain of the adverse effects associated with dredged material disposal and project flow regulation can be mitigated to some extent but not totally avoided.

NAVIGATION SYSTEM OPERATION AND MAINTENANCE

5.02
Continued operation of the project navigation system will result in occasional disturbances of the sediments of the channels due to dredging, removal of organisms and substrate, temporary increases in turbidity and chemical exchange in the streams at times of dredging, siltation, and associated ecological disturbances. Because of the short duration and infrequent requirement for dredging activities and the general physical, chemical and biological conditions of areas to be dredged, these impacts are expected to be relatively minor.

5.03
Some runoff from dredge materials deposited on land is unavoidable. Localized areas of high turbidity, siltation and increased chemical loads may occur in waters adjacent to the disposal sites. The use of stone rip-rapping or clay dikes will reduce but not eliminate erosion, particularly at times of high rainfall or during spring snow melts. There are a number of means by which the adverse effects of dredged material disposal have been partially avoided. These include such measures as structural containment of polluted sediment, and judicious disposal site selection.

5.04
In the aquatic disposal area to be diked and filled with dredged materials, a small lossof aquatic organisms and habitat is inevitable. When dredged materials are deposited on top of existing dredge material deposits or on new terrestrial sites, herbaceous plants, tree seedlings, and low shrubs will be covered and will suffer mechanical damage or mortality. Some insects, birds, amphibians, reptiles, and mammals inhabiting these areas will be destroyed or displaced to adjacent areas. The loss of habitat is not expected to impact any endangered plant or animal species inhabiting the project area.

5.05
Maintaining the required channel dimensions allows easy access for pleasure craft to and through the Lower Wolf River. Their use of the

channels promotes the secondary adverse effects, such as shoreline erosion, disruption of fishing activities, and destruction of the submerged and emergent natural vegetation of the river and of Lakes Poygan, Winneconne, and Butte des Morts.

THE OPERATION AND MAINTENANCE

5.06
Operation of the dams in the manner presently prescribed by law will result in the continued annual fluctuation of water levels and shoreline location above the control dams at Neenah and Menasha. The controlled fluctuations of flow, water levels, and shoreline locations, however, will be more advantageous to human interests than the fluctuations which would exist under uncontrolled conditions. In this sense then, control can be considered beneficial. Such control requires the expenditure of funds for both operation and maintenance of the dams. This expenditure is presently estimated to involve a direct cost of about $433,000 per year but is necessary to assure the benefits of navigation, flood control, flow control, hydropower capability, process water availability, and water quality control.

5.07
On the other hand, the authorized annual adjustment of water levels behind the Neenah and Menasha dams have contributed to the destruction of natural aquatic vegetation, which was formerly found in abundance in Lakes Poygan, Winneconne, and Butte des Morts. This loss of vegetation can be a significant factor in the reduction of aquatic habitat for fish and waterfowl. It is thought also to be a significant factor in the long-term degradation of fish spawning, waterfowl visitations, and loss of waterfowl habitat and food items such as wild rice, marsh hay, and other natural vegetation.

THE PROPOSED ACTION

5.08
Efforts to minimize or avoid certain adverse effects due to disposal of dredged materials and project flow regulation, and to maximize potential project benefits in the overall public interested, are limited by existing operational and maintenance activity authorizations.

SECTION 6

ALTERNATIVES TO THE PROPOSED ACTION

INTRODUCTION

6.01
The proposed Federal action is continued operation and maintenance of the Fox River, Wisconsin Navigation Project. As noted previously, the Fox River, Wisconsin Navigation Project involves two distinct and technically separable functions:

1. The operation and maintenance of the locks of the Lower Fox River, plus the dredging and snagging of navigation channels and harbors of refuge in the Lower Fox River, Lakes Winnebago, Butte des Morts, Winneconne, and Poygan, and the Wolf River.

2. Control of the 13 dams (9 U. S. and 4 private) on the Lower Fox River from Lake Winnebago to De Pere, plus maintenance and operation of the nine U. S. dams.

The following alternatives are discussed in terms of each of these major functions, but it should be remembered that the requirement to operate the navigation system places certain a priori restrictions on dam operation, namely, a guaranteed minimum depth of water through the Lower Fox River from 1 May to 1 November.

6.02
In addition to engineering, legal, and operational considerations, each of the alternatives was evaluated in regard to economic, social, and environmental aspects. In the process of selecting the proposed course of action, each of the following alternatives was fully considered and evaluated within the context of available data and existing land use plans and policies. There were no alternatives eliminated from consideration solely on economic grounds. On the balance, the various alternatives (either to or within the present project framework) were found to be less desirable than the selected plan.

ALTERNATIVES TO THE PROJECT

Abandonment of the Lower Fox River Navigation System

6.03
Cessation of all operation and maintenance activities on the Lower Fox River, including dredging and operation of the locks and dams, would abruptly halt through navigation; severely reduce pool surface elevations with consequent impact on water power, municipal and industrial water supply, stream sanitation and aquatic biota, and contribute to increased flood hazards throughout the Waterway. The annual expense to

operate and maintain the Lower Fox River portion of the system would be saved but additional costs would be incurred to remove or modify the structures, and there would be lost investments in the project structures and other facilities associated with operation and maintenance of the project. Implementation of this alternative would require a major change in the primary objectives of the project and would have such a great impact on the present socio-economic and environmental setting that it is considered a highly undesirable alternative.

6.04
Another course of action is to discontinue maintenance dredging and lock operation on the Lower Fox River while dams continue in operation. Since the cessation of commercial barge traffic (1959) on the Lower Fox River, the original Congressional intent of providing a practical system for the transportation of goods and materials into and out of the project area via water has ceased to be the primary reason for continuation of the navigation project. Today, virtually all waterway traffic is for recreational purposes. Furthermore, the number of recreational pleasure craft presently using the lock system for the primary purpose of through passage between Green Bay and Lake Winnebago is small. Viewed in this manner, the utility of the seventeen-lock Lower Fox River navigation system is in a sense limited to the provision of a slightly used but very expensive recreational passage from Green Bay to Lake Winnebago.

6.05
Cessation of dredging and lock operation while dams continue in operation would reduce or eliminate the non-navigational, adverse impacts cited in paragraph 6.03 above. There are also positive environmental effects associated with this alternative. This action would eliminate the detrimental effects on the natural environment caused by dredging, such as turbidity, loss of aquatic organisms and temporary decrease in water quality. These benefits must be compared in turn to the detrimental effects this action would cause on the man-made environment.

6.06
The Federal lock system abandonment alternative could either be carried out by totally removing the existing system or by securing the locks and reducing system maintenance to only that required to keep the locks available for future reactivation. Total removal of all of the locks would be very costly and would foreclose the possibility of future reactivation of the existing navigation system. Selection of the later option is considered to be the more desirable of these two possible courses of action because suspension of commercial navigation is not termination. The possibility of resumption of commercial navigation, though exceedingly remote, still remains until terminated by an Act of the U. S. Congress.

6.07
Abandonment of the Federal lock system need not completely eliminate recreational navigation on the Lower Fox River. While navigation between pools would for the most part be prohibited, canoeists could portage around the lock and dam sites. Powerboats would, however, only be able to travel within pools between dams, boat owners using the

system would be unable to navigate freely between Green Bay and Lake Winnebago, and a waterway access route to Lake Winnebago by the existing large number of river-based boats would be prohibited. Also, the pools between dams would become increasingly shallower and the volume of flow and storage capacities would be reduced due to undredged channels. This effect would further degrade the river environment and eliminate any movement upstream between pools by fish and other aquatic organisms. Presently the locks themselves offer avenues of fish movement when the locks are in operation. Although substitution of lock transport by lifts or other transfer apparatus could permit passage between pools for smaller recreational craft, the present waterway capability to handle larger craft and occasional water-land cargoes of dredging or construction equipment would cease. Furthermore, these alternatives were studied in detail and were found unsafe and inadequate to handle present and prospective traffic. It was concluded that abandonment of locks and cessation of dredging would greatly reduce the recreational benefits afforded by the existing lock operation.

6.08
Local interests are known to be strongly opposed to changes in the operation or care of the waterway because of the increasingly heavy boating traffic in the area. Locks are a crucial part of the waterway. Within the existing pattern of development local interests have constructed a number of small marinas and harbors to service the recreational traffic on the waterway. In addition to these developments, there are several hundred private boat piers, boat houses, landing platforms and berths for small craft around Lake Winnebago and the connecting lakes and channels. Many public and private launchings and boat lifts provide for access to the waterway. Other facilities are available in the area, such as picnic areas, restaurants, motels, taverns, etc. Abandonment of the lock system would adversely affect each of these public and private interests.

6.09
Abandonment of the locks would cause two other primary adverse effects. First, access to some dam structures for maintenance operations would be quite difficult if floating equipment could not be used. Presently, maintenance is accomplished by barges reaching the dams through the locks. Secondly, deactivation would require the one-time expenditure of time and money.

6.10
In conclusion, although the environmental effects of lock system abandonment would be primarily beneficial (cessation of dredging and dredged material disposal with their attendant aquatic and terrestrial impacts), the social impacts would be severe. Economically, the impact associated with abandonment of the lock system is less clear. As stated in Section 1 (Project Description), approximately one-third of the annual Federal expenditures for the Fox River Navigation Project are directly attributable to lock operation and maintenance. As the impact analysis discussion in Section 4 points out the economic justification of continued Federal expenditures for lock operation and channel maintenance will

be studied in FY 1978. And, although a detailed benefit/cost study of these expenditures is beyond the scope of this impact evaluation, the benefits and costs associated with operation and maintenance of the Federal lock system will neverthyless be examined, in detail, in this upcoming economic study.

Discontinue Project Maintenance Dredging

6.11
A variation of the preceding alternative would be continue Federal lock and dam operation but cease all maintenance dredging activities. This action would result in continued harbor and channel shoaling, thereby resulting in reduction in depths required to provide safe navigation for existing recreational and other traffic. Loose sedimentation after some accumulation would also be drawn into the locks when the valves of the locks are open. Such an accumulation of sedimentation would result in early operational problems in the opening and closing of the lock gates. Continuing sediment buildup in the lock chambers would lead to further operational problems and an eventual closing of the locks. As a result, this action would have serious adverse impacts on the social and economic human environments. The type of social and economic effects associated with cessation of dredging would be similar to those discussed in the preceeding abandonment alternative. The overall magnitude and extent of these impacts would, however, be greater due to the larger area and numbers of people adversely affected.

6.12
The natural environment also derives some benefit from the removal of polluted material from project channels. The dredgings will not remove all the polluted sediments, nor will their removal alone contribute significantly to the overall improvement in project area water quality. It would, however, represent a positive course of action toward improving conditions in these bodies of water.

Abandonment of the Lower Fox River Dams

6.13
The total abandonment of the Lower Fox River dams is not considered to be a viable alternative. The Neenah and Menasha dams continue to perform the valuable functions of flood control and flow control for the Lower Fox River, the lakes of the Winnebago Pool, the Upper Fox River and the Wolf River. The dams below Neenah and Menasha, while less essential for flow control and flood control, are important for establishing river pools for navigation, hydropower, and industrial process water.

6.14
Abandonment of the Menasha dam with the gates left in the open position would yield the following environmental advantages: a reduction of the present high water levels of the Winnebago Pool, possible decreased flood potential in the lower reaches of the Upper Fox River and Wolf River, a significant contraction of the lakes of the Winnebago Pool, and an increase in the amount of marshlands around the lakes. This action,

however, would cause the social disadvantages of loss of direct water access to the lake by the towns, marinas, and individual property owners presently located along the lakefronts; severely low flows through the Lower Fox River with consequent loss of hydropower, process water, and water quality control. If the Menasha Dam were abandoned with the gates left in the closed position, water levels in the Winnebago Pool would frequently rise to flood levels, flooding of the lower reaches of the Upper Fox River and Wolf River would be frequent and severe, and very low flows through the Lower Fox River in winter would be experienced.

6.15
Under the terms of the deed by which the United States acquired the Fox River navigation improvements, the water power owners are entitled to use all surplus water not needed for navigation under the approved plan for the regulation of Lake Winnebago. Continued maintenance of Government dams is essential for the development of the water power available. The construction of the dams and maintenance of these structures accrues to the power interests a benefit. The rights to use the surplus water would be of little value if it were not for the maintenance performed by the Federal Government. The energy replacement cost to companies with hydroelectric facilities (see Table 6.1) on the Lower Fox River is at least \$1,462,724 for lost hydropower capacity on an annual basis. The Kaukauna Water and Electric Department would incur the largest loss. Since operation and maintenance of the dams cost \$432,567 in 1975, over three times as much money (in the form of electrical energy) as is presently spent operating the dams would be lost by abandoning them.

Transfer of the Federal Navigation Project to the State or Commercial Interests

6.16
The navigation system on the Lower Fox is presently unused for commercial barge transportation and prospects for its future use for this purpose seem unlikely. Because the primary value of the system is a recreational one, transfer of control of the navigation system to the State and/or local municipalities can be considered a viable alternative. The recreational values afforded by the project may well be more properly a State or local function than a national one, since no Federal recreational lands are located adjacent to any of the project waters and the recreational benefits derived accrue (for the most part) to a somewhat limited geographical area located entirely within the State of Wisconsin. As a sub-alternative to previously discussed abandonment alternatives, one or more of the most frequently used upstream locks could be left in operating condition but turned over to the State of Wisconsin, a local public agency, or private operator for control and operation. In this manner, Federal control (and expenditures) for the project would cease. A precedent for this alternative was established in the 1962 transfer of the former Upper Fox River portion of this project to the State of Wisconsin for the purposes of conservation and recreation.

6.17
In a similar manner, responsibility for operational control and maintenance of existing dam structures could also be transferred to the

Table 6.1. The Value of the Project to All Companies with Hydroelectric Facilities on the Lower Fox River[a]

Companies with Hydroelectric Facilities	All Electricity Used or Produced, kWh/yr	Value of All Electricity Produced and Purchased, $/yr	Hydroelectricity Used or Produced, kWh/yr	Cost of Hydroelectricity Used or Produced, $/yr	Add'l Cost to Co. if It Lost All Hydroelectricity, $/yr	Value of the Corps Maintaining Hydroelectric Power	Value of the Corps Maintaining Adequate Availability of Quality Process Water
Appleton Machine Co. (NA)[b]							
Appleton Papers Div, NCR	190,119,500[c]	1,827,707[c]	21,589,500[d]	64,300[d]	190,423[d]	Valuable	Valuable
Consolidated Papers Inc.	30,709,566	512,404	1,428,600	21,831	2,885	Valuable	Valuable
Foremost Dairy (NA)[b]							
Fox River Paper Co.	22,503,990	323,117	7,568,990	66,000	97,185	Valuable	No value
Geo. A. Whiting Paper Co.	4,128,000	89,638	375,000	3,000	5,143	Valuable	No value
Kaukauna Electrical and Water Dept.	118,354,703	1,622,558	100,448,803	220,315	1,036,288	Valuable	No value
Kimberly Clark Corp.	189,097,000	2,843,800	6,951,000	69,500	46,800	Valuable	Valuable
Nicolet Paper Corp.	72,086,000	1,507,370	2,843,995	NA[b]	84,000	Valuable	Valuable
Wisconsin-Michigan Power Co.	2,850,000,000	51,500,000	9,113,000	NA[b]	NA[b]	Valuable	No value
Total	626,998,759	8,726,594	141,205,888	>444,946	>1,462,724		

[a] All data provided in 1975 by the companies listed.

[b] NA = data not available.

[c] Deletes unreported cost for steam turbine generation.

[d] Deletes maintenance cost of hydroelectricity.

State. This would provide the State with overall direct control of Lake Winnebago lake levels and downstream flow regulation on the Lower Fox River. The environmental and social impacts which would result depend upon the precise management actions, if any, the State elected to take.

6.18
It is important to note, however, that while the project as it presently exists offers many direct and indirect benefits to the State, the project is expensive to operate and maintain. Whether in the final analysis the State would have the willingness and capability of resuming this large financial and operational management responsibility is currently unknown.

6.19
Transfer of the authority and responsibility for the navigation system to a private agency is also possible; however, this alternative is not considered to be a viable one since it is unlikely that the venture would be sufficiently profitable.

ALTERNATIVES WITHIN THE PRESENT PROJECT

Dredging

6.20
Partial Maintenance of Project Channels - Every several years, the canals between the locks and the channels approaching the locks require frequent maintenance dredging and even more so than in other reaches of the river to maintain project depths. This is usually the shortest period required for maintenance dredging. A good portion of the river channels retain their depth naturally and do not require dredging for long periods of time.

6.21
The possibility that currently authorized project depths are not now required was considered. Although authorized channel limits are set by law, dredging to less than authorized depths is permitted.

6.22
On some waterways the needs of navigation can be met adequately by dredging to less than the authorized project depth. This is not believed to be the case in connection with the Fox Project, however.

6.23
Present authorized channel dimensions on the Lower Fox River are a width of 100 feet and a depth of 6 feet below standard low water, which is the low stage with pool levels maintained at the crests of the controlling dams, and is the stage below which water users may not draw water from the pools during the navigation season. The minimum safe depth on the Lower Fox River is considered to be 6 feet. This depth is based on a vessel draft of 3 feet, a normal squat of one foot, allowance for wave fluctuations of one-half to one foot, and a minimum clearance under keel of one foot. An additional depth of 1 foot in rock cuts above De Pere is required to permit safe use of the controlling depth of 6 feet,

since small boulders frequently are loosened by the current of the river, ice action, or propellor wash and deposited on the channel bottom. Added depth of 3.6 feet in the channel below De Pere lock is required because of the aforementioned loose rock hazard, and the fluctuation of the water level due to seiches and storms on Green Bay to about 2 to 3 feet below the prevailing lake level. While the drafts of many of the recreational power craft using the Lower Fox River is 3 feet, it should be noted that the largest of the recreational boats recently reported using the Fox River and Lake Winnebago waters was a boat 74 feet 10 inches by 15 feet 6 inches with draft of 5 feet and the prevailing trend toward the use of larger boat motors is expected to increase the proportion of boats with drafts over four feet. Finally, sailboats and the Corps vessels and barges which are used to maintain the canals, channels, locks and dams also need the full project depth to traverse the waterway.

6.24
Channels normally require widths of five (5) times the beam of the largest craft using the waterway. Many recreational craft using the Fox Waterway have beams of 17 feet or more in breath and since the government barges which maintain the waterway have beams of 30 feet, the present project width of 100 feet is considered reasonable. Operating hazards and exposures to strong river currents also justified maintaining the present width of 100 feet.

6.25
Lake Winnebago is a large shallow body of water 28.25 miles long with a maximum width of 10.75 miles and a maximum charted depth of 21 feet. The normal low water area is about 206 square miles. Because of its shallow depth and large open surface the lake is subject to violent wave action developing quickly during summer storms. Several hundred small boats may be in use on the lake for fishing and recreation at one time. Many of these boats are small outboard motor boats, but cruisers up to 50 feet in length and with draft of 5 feet often are included. For safety, these boats should not be farther from an adequate harbor of refuge than the distance they can cruise in about 30 minutes in rough waters. This indicates that a safe refuge should be available at intervals of about 10 miles along the lake shore, and at about 5 miles from any point in the lake. The existing Federal harbor improvements on Lake Winnebago, with bays along the west shore affording some natural shelter, meet the requirements for shelter needed. Although the small harbor at Brothertown is only about 3.5 miles north of Calumet Harbor, the elimination of the former harbor would leave areas in the widest part of the lake 6.5 miles or more from an adequate refuge. Maintenance of 6 feet channel depths at the Lake Winnebago harbors is needed to provide safe operating conditions for recreational craft with vessel drafts of about 3 feet after making appropriate allowances for wave fluctuations, squat and minimum clearance.

6.26
If dredging for harbors of refuge were reduced or abandoned in Lake Winnebago, large pleasure boats would not be able to take refuge in the

harbors during bad weather. Since only two percent of the annual project budget (an average of $15,012 per year over the last five years) has gone for dredging the harbors, large economic savings are not anticipated. The purpose of this dredging is to save lives and the only reason for abandoning the dredging would be to avoid the adverse impacts of dredging and dredged material disposal. These impacts are not considered to be great. No less costly alternative to the dredging of harbors of refuge on Lake Winnebago are known which would be impact-free but which would provide the same measure of safety for boaters during stormy weather.

6.27
The draft of many of the recreational power craft using the Wolf River is 2 feet. Shoals and snags in the channel upstream from Freemont prevent even some of these boats from proceeding upstream as far as New London at times. The minimum safe depth on the Wolf River is considered to be 4 feet. This depth is based on a vessel draft of 2 feet, a minimum allowance for squat and wave fluctuation of one foot, and a clearance of one foot above the soft bottom. Undoubtedly, many more boaters would enjoy trips through this scenic portion of river channel if a clear channel with greater depths were made available.

6.28
If present regulations were changed, it would be possible to reduce or eliminate dredging activities in Boom Bay and the Wolf River and limit use of the channel to small powerboats only. This would lessen erosion due to the wakes of larger, more powerful craft, enhance the fishery, and improve the marshlands for wildlife. A significant economic saving is not anticipated if dredging activities were stopped. The costs have been about two percent of the project budget and averaged $15,332 per year over the last five years.

6.29
Partial maintenance would result in a reduction in the amount of material to be dredged and disposed of and a resultant decrease in maintenance costs. However, it would have similar negative economic effects to "no action" alternative. The extent of the economic effects would be determined by the depth to which dredging is done which influences the number and type of vessels which can be accommodated on any given portion of the waterway system. Because dredging and disposal would still be required by dredging to a lesser depth, there would generally be no significant environmental advantage to this alternative.

6.30
Alternative Dredge Operation - At present the type of dredge plant used on a project is based on the amount and type of work to be accomplished, the availability of dredge equipment and the economics of the project. The environmental compatibility of one dredge type over another has not yet been well enough documented to make environmental compatibility the primary basis for selecting dredge type. Continued use of a clamshell dredge is proposed for maintenance of project channels because of its practicality and effectiveness. Alternative methods of dredging were considered in selecting the proposed action.

6.31
All methods of dredging increase the levels of turbidity by nature of the dredge operation. Because of this practice, the suspended solids and dissolved solids in the work area of the dredge are increased, creating a sediment plume.

6.32
Equipment for dredging operations falls into two classes: mechanical and hydraulic. The dipper and clamshell dredges are mechanically-operated dredges while the pipeline and hopper dredges are hydraulically operated. When excavation is by mechanically operated dredges, auxiliary equipment consisting of scows and tugs is required to receive the dredged material and transport it to the disposal site. Hydraulic dredges combine the digging and disposal operations in one piece of equipment. The principal types of dredging eqiupment are as follows:

- Clamshell or Dipper Dredge

- Pipeline (Suction/Cutterhead) Dredge

- Hopper (Suction) Dredge

6.33
Clamshell or dipper dredge type of equipment is used to excavate the sediments and place them in a scow located alongside the dredge. The dipper dredge is especially useful for new work dredging and breaking up hard, compacted material, including some types of ledge rock. The clamshell dredge is used, for the most part, to excavate soft or cohesive underwater materials, and is exceptionally useful for deep digging and for dredging to close quarters alongside structures.

6.34
A pipeline dredge type has a pumping unit that sucks up material at the intake end of a section pipe located at the forward end of the dredge and discharges the material to a trailing pipeline to the disposal site. Pipeline dredges are used most frequently for d[illegible]ging sandy, clayey, or silty bottoms which have sufficient depths of [illegible] for economical operation.

6.35
A hopper dredge utilizes a pump to suck the sediments through a pipe into hoppers onboard the ship where they settle. The fines and excess water overflow at the top of the hoppers. When the hoppers are filled with sediment, the dredge itself transports the load to the disposal site. The hoppers are normally emptied by bottom dumping or by pumping into the disposal site.

6.36
Clamshell and hydraulic are the two types of dredges which may be used on the Fox Waterway. These dredges are pictured in Figures 6.1 and 6.2, respectively. Water depths in the project area are too shallow for hopper dredges to operate.

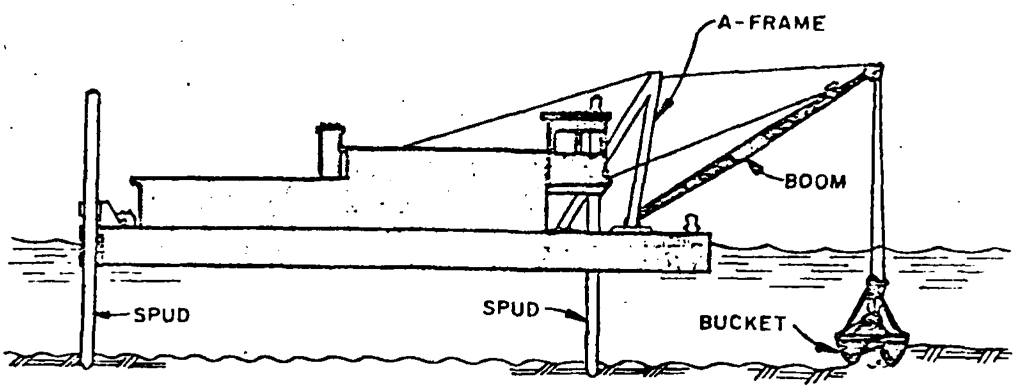


Fig. 6.1. Clamshell Dredge.

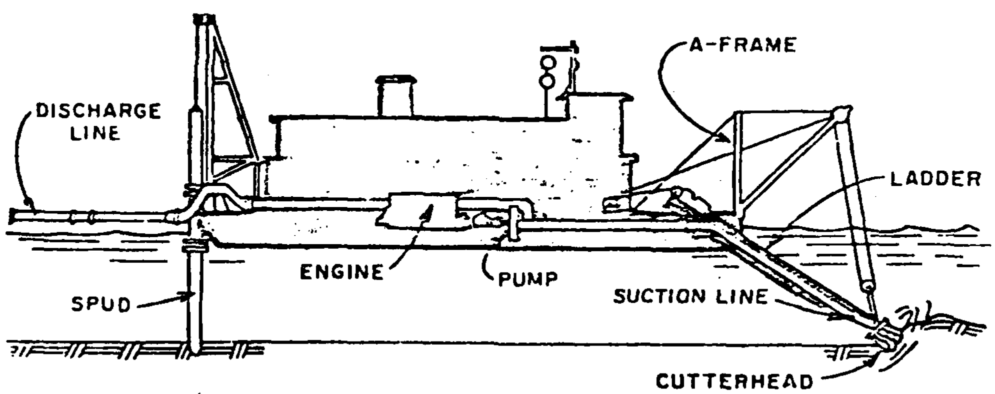


Fig. 6.2. Pipeline Dredge.

6.37
Although all dredging processes cause turbidity, sediment concentrations would be greatest with the mechanical dredge equipment and least with hydraulic dredge types. Pipeline dredges, therefore, have advantages in terms of potentially limiting biological damages associated with turbidity. While the intensity of the short-term effects of clamshell dredging might be high, however, the duration and range are relatively small. Pipeline dredging has the disadvantage of being uneconomical for small dredging operations.

6.38
The choice between the two methods also makes a difference in the impact of material disposal. Materials dredged by conventional bucket dredge generally cannot be deposited on shore without one or two rehandlings, which materially increases the cost of the work. If the area to be dredged is near the disposal area, the use of a hydraulic type dredge with pipeline to the point of disposal may be a more economical alternative in some instances. Hydraulic pumping, however, has the disadvantage of bringing large amounts of water to disposal areas. At project locations where polluted dredgings are to be confined, this would significantly increase the size of areas needed for disposal. Special dike design and disposal site operational features would also be required, thereby greatly increasing disposal costs. Assuming that suitable diked or on-shore disposal areas can be arranged, hydraulic dredging could be employed advantageously at the harbors on Lake Winnebago, and probably at certain lower Fox River areas such as the channel below Menasha Lock. In the event that the Wolf River segment of the project is to be completed to full project depth the use of a hydraulic dredge with dredged-material disposal on the lowlands bordering the river undoubtedly would be most advantageous.

6.39
Considering the present limited knowledge concerning exact impacts and degraded aquatic conditions in the project area, little difference can be shown between the environmental impacts as well as the social and economic effects of the different types of dredging equipment. Based on current knowledge, the type of materials to be dredged and the degree of contamination of the sediments have a greater influence on environmental impact than does the type of equipment. Research presently being conducted by Waterways Experiment Station at Vicksburg, Mississippi should aid to clarify which dredging types are the most compatible with the environment.

Alternative Dredged Material Disposal

6.40
There are number of methods by which dredged materials may be disposed. These methods were evaluated for their applicability at each of the proposed dredging locations.

6.41
<u>Treat Polluted Dredged Material Prior to Disposal</u> - In previous studies the Corps has investigated the possibility of treating dredged materials in existing waste-treatment plants, in separate special plants, in mobile units, and onboard dredges. Even the least costly treatment process was found to involve many times the cost of most other alternative conventional disposal practices, including disposal in diked areas. An added disadvantage of the method is the need for a disposal site for the dredgings after they are treated and, in certain processes, the need for a temporary storage site before treatment. Since the treatment of the material appears to be much more expensive and possibly no more effective than the proposed method and because the social and environmental considerations would be similar to those of the selected project, this course of action was rejected.

6.42
Discontinue Dredging Until All Disposal Sites Are Secured - Dredging has become critical at several project locations and the responsibility for maintaining the project lies with the Corps. The Chicago District does not feel that it is necessary or appropriate to discontinue all project dredging and disposal until formal disposal plans are approved at all project dredging locations. Because future maintenance dredging is subject to the disposal of dredged materials at approved sites, there would be no environmental advantage to discontinuing project maintenance activities at locations where dredging and disposal impacts are minor and have already been full coordinated and approved by other Federal and State agencies.

6.43
Alternative Confined Sites - For the canals and channels along the Lower Fox River, through a densely settled and highly developed industrial area, the only practical way to dispose of polluted dredge materials without adding to the suspended sediment and pollution load of the river appears to be containment within areas enclosed by dikes. Confinement of polluted dredged material will eliminate the potential adverse impacts associated with previous disposal practices.

6.44
The possibility of utilizing other disposal areas in the vicinity of the project was considered. Prior to the final selection of proposed confined disposal sites, investigations were undertaken to examine potential alternative land and water sites. These initial sites were then evaluated in greater detail and those that were determined less suited for use as disposal sites were eliminated from further consideration. A preliminary plan for the Fox Project was subsequently presented in the draft environmental statement. Since the release of the draft statement, certain proposed disposal sites were deleted from the final plan on the basis of comments resulting from agency and public review of the draft statement and coordinated Federal/State agency field inspections of disposal sites.

6.45
Land Disposal of Dredged Materials - The Chicago District is not authorized to purchase any additional lands for dredged material disposal under the present operation and maintenance project authorization for the Fox River, Wisconsin Navigation Project. This proved to be an important consideration in the evaluation of alternative land sites. Only those lands which are Federally owned or made available by local interests can be developed as disposal sites. Local interests, which receive the most benefit from the project, were not always able or willing to furnish needed disposal sites. Fortunately, existing Federal properties were, for the most part, adequate to meet current short-term disposal site needs in an environmentally acceptable manner. Because the available supply of suitable sites is so limited, however, long-term dredging and confined disposal will likely depend almost entirely on the cooperation of local municipalities, etc., in offering suitable sites which meet both operational and environmentally acceptable criteria.

6.46
Water Disposal - Policy Considerations - Present Federal policies require the containment of polluted dredgings. In accordance with Federal EPA criteria and guidelines, polluted dredgings may be disposed of on shore or within completely confined lake or river areas. Unpolluted dredgings are considered to be generally suitable for unrestricted disposal. Current State policy with regard to dredged material disposal, however, requires that essentially all material dredged from lake or river waters must be disposed of on suitable land sites. It is the State's position that disposal of dredgings on the bed of a navigable lake or river would be contrary to the Public Trust Doctrine to preserve navigable waters within Wisconsin. The trust doctrine maintains that all navigable waters are held by the state in custody for all citizens and the state has the authority to control anything which affects the natural character and use of navigable waters. Public rights to surface waters consist of not only navigation but of incidental uses such as hunting, fishing, swimming, wading, skating, and the enjoyment of scenic beauty. It is the position of the Wisconsin DNR that the deposition of dredged material upon the bed of a navigable waterway is contrary to these rights. The Wisconsin DNR does not make a distinction between private filling within a natural water body and Federal disposal of dredged materials on the bed of a lake or stream in connection with Federal maintenance of a navigable waterway.

6.47
The Wisconsin Department of Natural Resources also holds that deposits of dredged materials in navigable waters, regardless of the physical or chemical character of the sediments, is contrary to state responsibilities to prevent pollution and to protect waters of the state from degradation.

6.48
Irrespective of the above and pursuant to state legislative statute, the Department may permit limited fill encroachment on navigable waters by riparian owners provided such encroachment does not materially obstruct navigation and is not detrimental to the public interest. At the time of this writing, however, the Department has not elected to approve any offshore project-related discharge of dredged materials.

6.49
In keeping with the wishes of the State DNR, the Chicago District has deleted certain otherwise suitable confined water disposal sites from the final disposal plan. Several such sites were described in the draft environmental statement for the Fox Project. Two such sites are unused turning basins no longer required for the navigation system. Since neither of these sites is a natural feature and each, if filled, would return some of the stream bed to a more natural condition, no significant adverse impacts from the proposed filling of these sites was anticipated.

6.50
In Lake Disposal - Open water or in lake disposal of unpolluted dredged materials within Lakes Poygan and Butte des Morts has been a common practice of the Chicago District for years. Suitable offshore disposal areas have been fairly accessible and, until recently, been readily acceptable. The District disposal plan for these locations recommends continuation of "open water" disposal in a manner which is intended to mitigate wetland and marshland habitat losses experienced in the associated upriver lakes region. The disposal plan concept for this region features diking to protect existing marsh in the Wolf River (Boom Cut) from destructive wind and wave action and diking and filling to develop additional marsh area through regulated dredge material disposal and plant recolonization in the Lake Butte des Morts area (see Figs. 6.3 - 6.6). However, for the reasons previously stated in paragraphs 6.46 - 6.47, the Wisconsin Department of National Resources favors some type of land disposal alternative.

6.51
The District proposal to continue the current practice of in lake disposal (with modification for environmental enhancement purposes) is based on three primary factors. These factors are comparatively low cost, conformance with established Corps policy, and relatively minor adverse environmental impact.

6.52
The first factor involves the cost considerations that must be considered in programming Federal monies for project operation and maintenance. This is important because the removal of large volumes of bottom material and relocation of this dredged material to more distant disposal sites greatly increases disposal costs. Materials removed from the upriver lake area could be deposited on land sites. Land disposal could be accomplished by either pumping dredgings via a pipeline from the transporting scow to the disposal site, or truck transport. However, based on a preliminary examination the cost of land disposal for this portion of the waterway system, the land disposal alternative increases disposal costs several fold and is considered to be prohibitive. In addition to normal dredging expenses, scows must transport the dredged material to a site in close proximity to the fill area. A pipeline system, with auxiliary pumps, must be installed between the scow's docking site and the fill area. Costs for construction of this system increase markedly with an increase in the pumping distance. Transfer of dredging to trucks requires a suitable docking area assessible to loaded scows. Trucking involves substantial additional cost.

6.53
The second factor is related to both general Federal and specific Corps policy considerations. Federal policy allows the discharge or placement of unpolluted dredged fill materials in navigable waters and Corps policy provides that where local authorities disapprove of this practice, that state or local interests must assume the additional costs associated with an alternative agreed upon disposal plan. The only alternative is to suspend dredging operations.

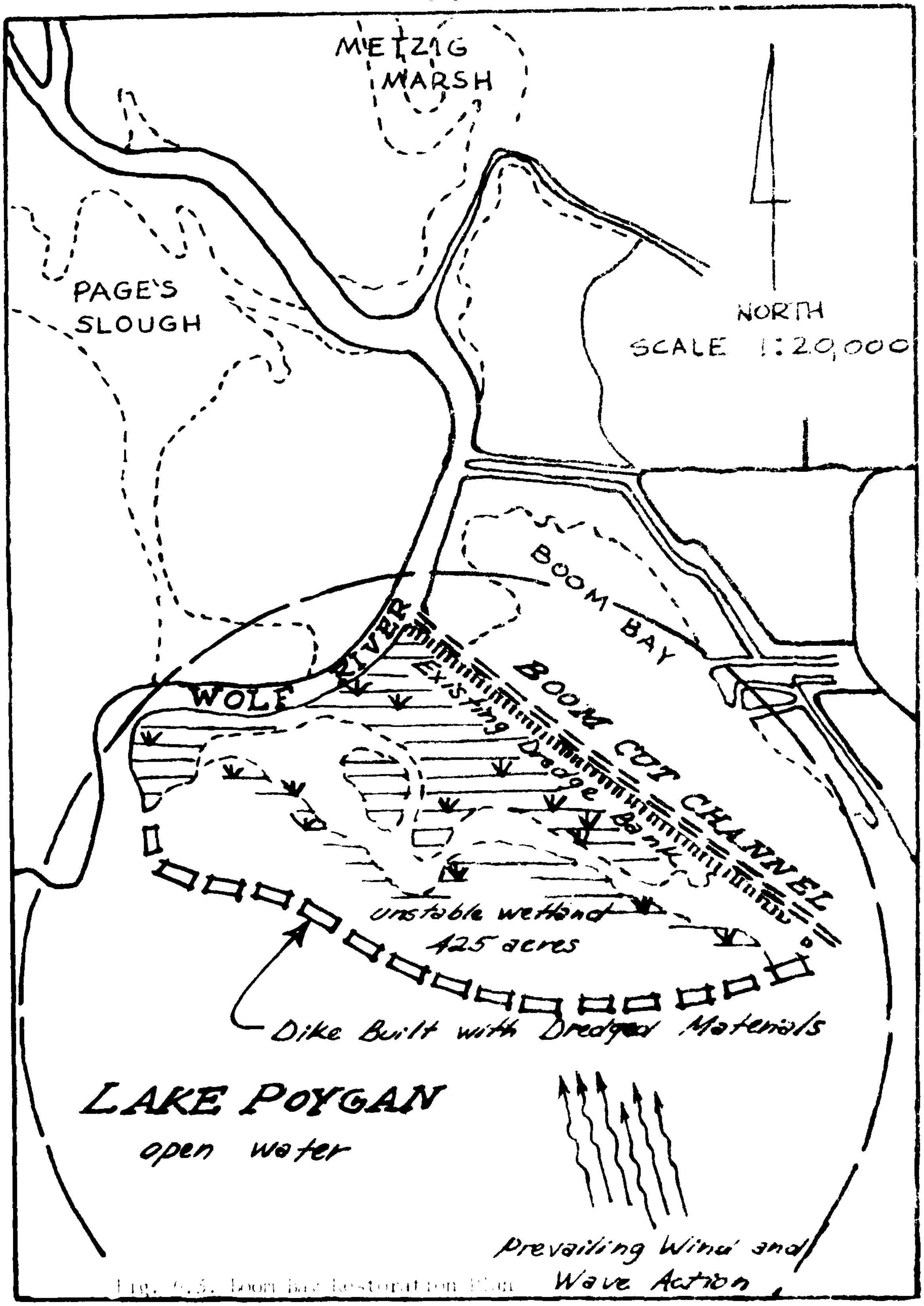


Fig. 6.5. Boom Bay Restoration Plan

Fig. 6.4. Use of Dredged Material to Create

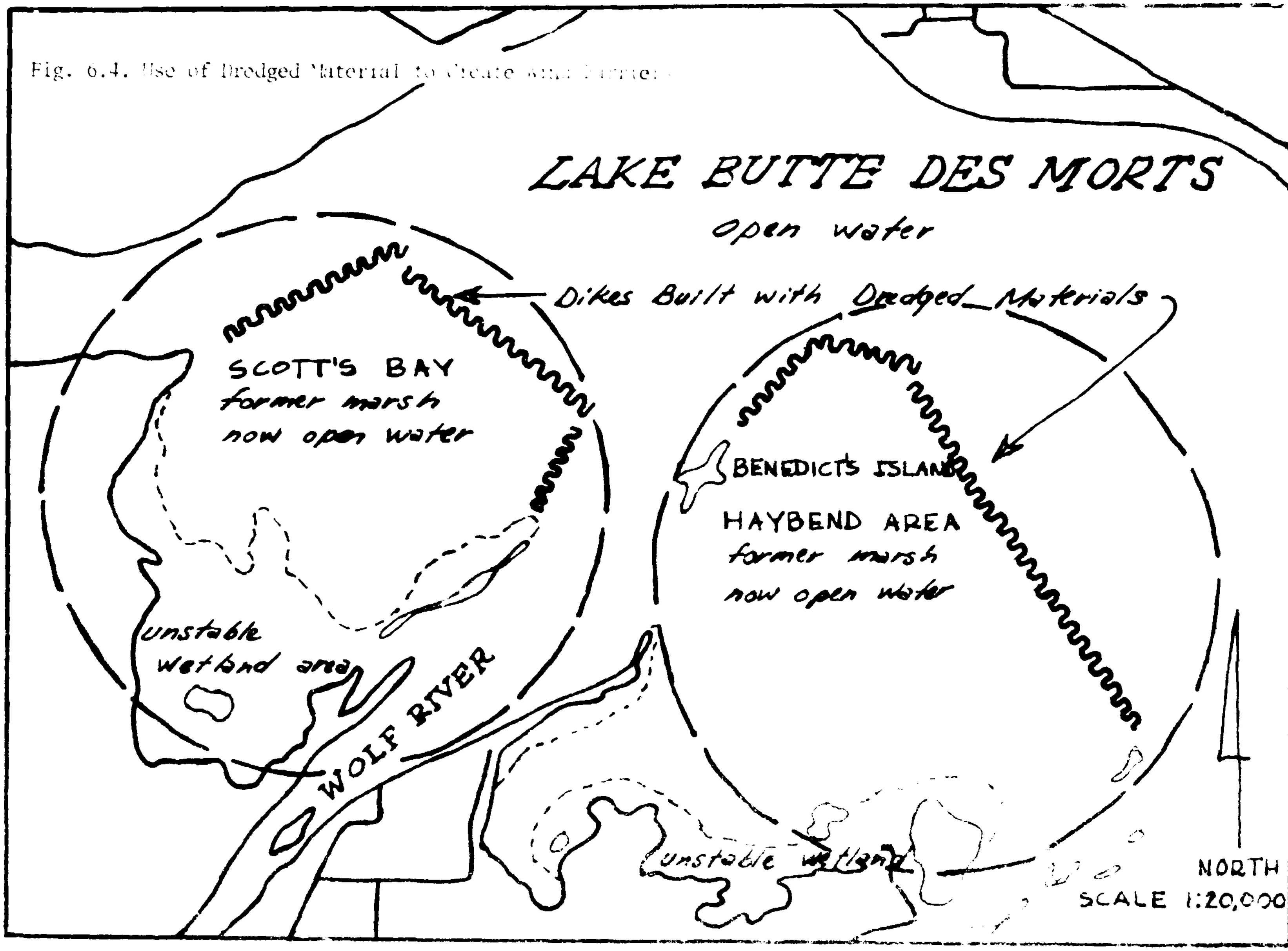
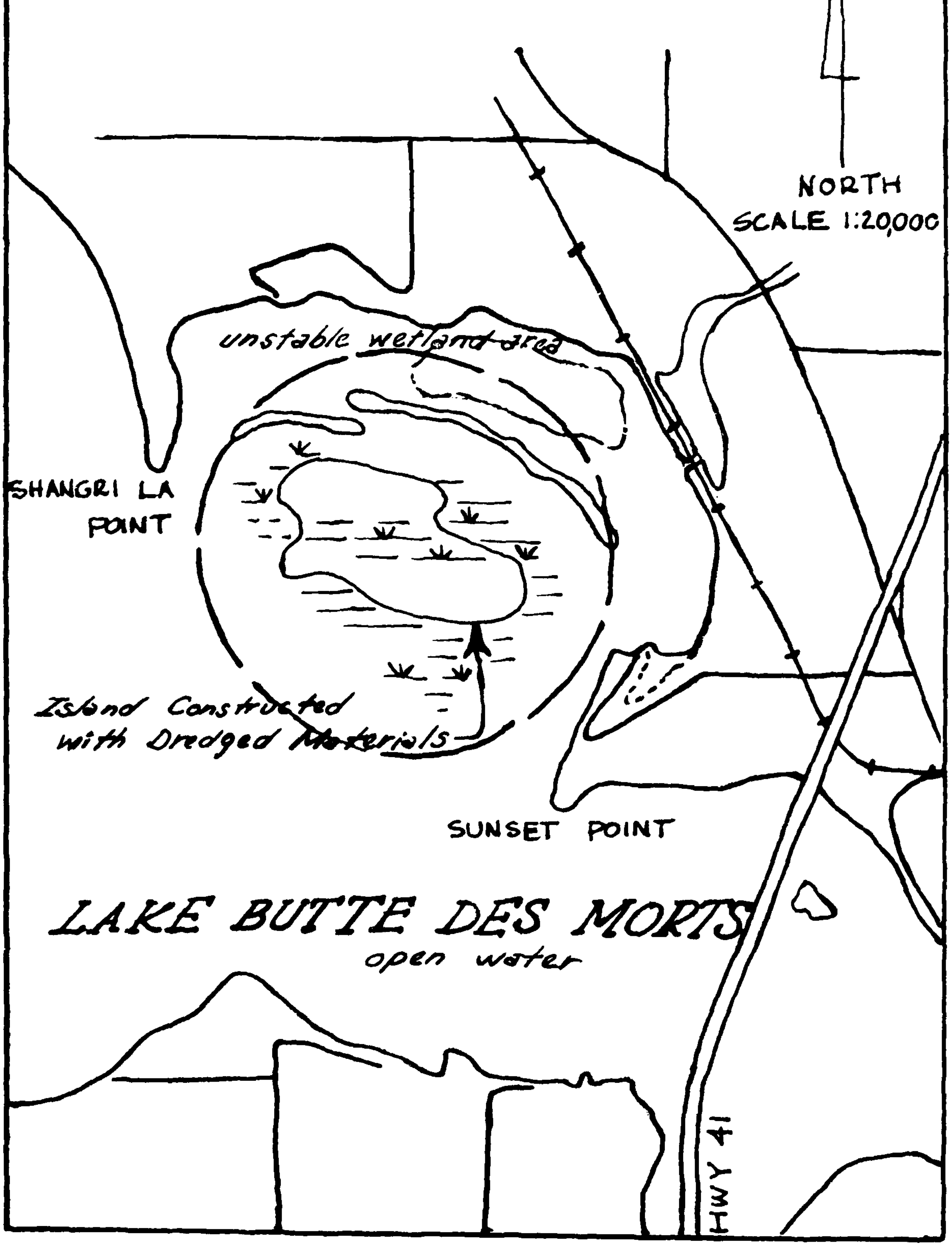
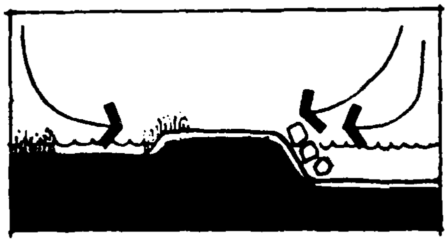


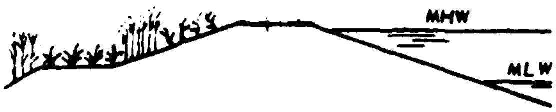
Fig. 6.5. Use of Dredged Materials to Create Marsh



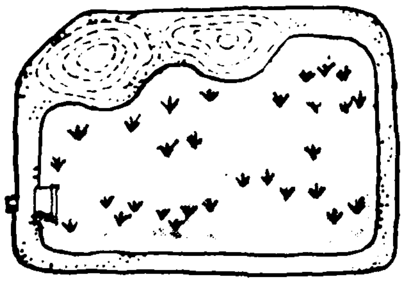


Experimental construction of break-waters and dikes to protect former marsh areas from wave action and help regenerate vegetative cover in these areas.

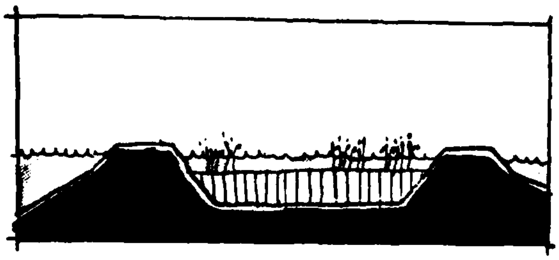
Experimental construction of sur-face and sub-surface sand bars and islands which can be used for the purpose of establishing aquatic cover and regenerating marsh con-dition.



Experimental construction of berms along the edges of dikes and break-waters to establish aquatic cover plants and to provide protection from possible muskrat damage to es-tablish dikes.



Investigation of the possibilities of consturcting water tight diked areas which would permit water level control via pumping.



Construction of dikes to confine dredgings at suitable depths for establishing and maintaining aquatic cover.

Fig. 6.6. Useful Dredged Material Disposal Applications

6.54
The third factor involved in the question of in lake disposal for marsh construction and/or enhancement purposes is the Chicago District's belief that disposal along the suggested lines would have significant, overall beneficial environmental impact.

6.55
For these reasons, the Chicago District is unable to dispose of dredged materials taken from Lakes Poygan and Butte des Morts in the manner (upland disposal) currently proposed by the state. Rather, the District has requested further state consideration of alternative in-lake disposal concepts designed to artificially create or maintain marshlands and wetlands. Dredging operations at these locations will be suspended until this matter is resolved. Additional information on some of the environmental impacts, values, and considerations involved in this type of undertaking are provided in the following paragraphs.

6.56
Dredging has been associated with ecological degradation in the past primarily because of the concomitant practice of disposing of polluted dredge material in open water. Open water disposal of polluted dredge material is considered presumptively undesirable because of its possible long-term adverse effects on the ecology of aquatic environments. Guidelines for determining the acceptability of disposal of dredgings in a waterway have been established by the Federal Environmental Protection Agency (EPA). Adherence to these guidelines will generally preclude adverse impact but the actual impact experienced will be determined by the local chemistry of the receiving site.

6.57
Bulk sediment tests performed on dredge material specimens from the upriver lakes region indicate that dredgings from this area are unpolluted and suitable for unrestricted disposal (see Table B.9, Appendix B). Prior to the implementation of any possible marsh construction or enhancement program the Corps and State DNR might agree upon in the future, however, testing in accordance with new EPA interim guidelines for sediment evaluation would be required. These procedures (Table B.10, Appendix B) are based on the water extraction of sediment material under prescribed conditions. As such, it is believed that these analyses would have a higher correlation with actual disposal site environment effects than previous guidelines based on the older test procedures. This additional precaution should insure no long-term adverse impact on the aquatic environment as a result of inlake disposal.

6.58
The potential short-term impacts of inlake disposal are similar whether for the purpose of island raising, island or shoreline building, breakwater or jetty windbreak development, or for the purpose of creating more favorable lake depths for the establishment of marsh plants. These impacts include excessive turbidity and siltation, possible release of toxicants, and dissolved oxygen reductions due to release of organics. Wave action and high flow conditions would also constantly cut away at the deposits.

6.59
Filling would not only have a significant physical impact on the area but would have a substantial biological impact as well. Biological abundance and diversity in affected areas would be essentially destroyed by the filling process. This would in turn place a stress upon the balance of the surrounding aquatic ecosystem. It must also be noted that there is no guarantee that the resulting terrestrial and aquatic habitat produced would be as, or more, productive and useful as the aquatic habitat replaced.

6.60
In contrast, the potential benefits of wetland re-establishment, protection, and enhancement to improve wetland habitat for wildlife, fish and recreation are great (See 2.224). Furthermore, in the absence of some sort of successful marsh restoration program, a continued decline in the aquatic habitat of the upriver lakes region will occur. For reasons previously discussed, continued loss of floating marsh seems inevitable. Once the floating marsh is gone from an area, waves and currents remove bottom materials, thereby making the water deeper than most marsh plant species are able to tolerate. Additional vegetative losses are likely to follow as adjacent areas of emergent and submergent vegetation are subjected to increased turbidity and wind and wave exposure.

6.61
The above suggests that dredged fill material disposal should be directed towards providing suitable substrate for development of vegetative cover, establishment of physical barriers to reduce wave action in critical areas, and dike construction for the purpose of water level control.

6.62
Since lake depth and wave energy appear to be the major factors controlling marsh growth on the upriver lakes area, no marsh restoration project is likely to be successful unless it provides for shallower water, as by filling. Natural filling can probably also be induced by breakwaters oriented so as to reduce the size of wind-generated waves (i.e., oriented perpendicular to the direction of prevailing wind), but there is no data to indicate the rate at which natural filling would occur.

6.63
Emergent aquatic cover can be established on surface and subsurface sand bars constructed with dredged fill material if the substrate and optimum water depth requirements of the plant species to be developed are met. To assure that the area affected is minimized during the established period, shifting and washout of filled materials can be prevented by construction of a riprapped dike around the disposal site in some cases. If it is desired to increase the abundance of these species by management practices, direct planting of their perennating organs (rhizomes) is probably possible.

6.64
Breakwaters and diking can be designed and constructed in a manner so as to either protect existing marsh areas or protect former marsh areas from wave action and help regenerate vegetative cover. Since waves do not stir up as much sediment in the deeper portions of the lakes, efforts to reduce wave action should be concentrated in the more shallow portions of the lakes. Perhaps with a series of breakwaters strategically placed in relation to the prevailing winds it would be possible to break up some of the large expanses of open water and reduce the intensity of wave action. The reduction of wave action and the physical aspect of the barriers could also have the following additional beneficial effects:

- Water turbidity could be expected to decrease.
- Properly located barriers could provide smoother water for small craft on windy days.
- Further bog losses should be reduced.
- Barriers could provide cover for waterfowl and their broods.
- They could provide concealment for waterfowl hunters and spread out the hunting pressure over areas which are presently covered with open water and unsuitable for hunting.
- They could provide cover for fish in areas presently devoid of aquatic vegetation.

6.65
Finally, dredged fill can be used to strengthen and extend existing dikes and dredge banks. Water tight diked enclosures can be constructed for the purpose of establishing vegetative aquatic cover under controlled water conditions.

6.66
The primary objective in each of the above approaches is the productive and economically efficient use of dredged fill material resources. The recommended plan to experiment with the use of dredged material in this manner has the advantage of potentially providing a means of dredged material disposal which is both operationally and environmentally acceptable.

6.67
It is the Chicago District's intention therefore to continue to pursue this idea through appropriate Federal and State agency channels. To this end, the Chicago District is ready to work with State and Federal fish and wildlife agencies in the research, development, and evaluation of the feasibility, methods and criteria for implementing an in-lake disposal program along the lines suggested above. The District is further prepared to partially fund the research and development of such a program. It is our belief that this type of productive use of dredged material resources is in the best overall public interest.

Lock Operation

6.68
Presently the project has some navigation problems such as total lockage time and the number of locks involved. The Fox River also has a limited navigation season and there are high velocity currents during flood flow stages. The miter type gates of the present locks are operated by means of a hand powered capstan applying power to a small pinion which meshes with a gear rack on the gate spar. This is a slow operation with one lockman on duty. To modernize the existing system, electrically powered operation could be provided at the existing locks.

6.69
The locks could be operated on a toll basis by charging each user a fee, which would help pay for the operation and maintenance of the locks. Any attempt to assess a toll (especially one based on actual cost per craft locked) would probably result in a severe reduction in system usage by recreational boaters. Furthermore, operation of the locks on a toll basis is not possible under present authorities.

6.70
Number of Locks - One navigational difficulty is the number of lockages that are necessary to move traffic through the Lower Fox River. Seventeen lockages are required for movement from Green Bay to Lake Winnebago. The time consumed by each lockage is approximately 10 minutes, so a minimum of about 4.33 hours of lockage time would be involved in each one way trip through the waterway, or 8.5 hours for a round trip. Such delays discourage trips between Lake Winnebago and Green Bay or Lake Michigan, such movements often being limited to single seasonal trips between operating bases. Some reduction in the time required for lockages would be possible if equipment for power operation of the gates and valves was installed, but renovation of the entire system would be very costly.

6.71
Under present regulations limiting lockage service without prior notice generally from 10:00 A.M. to 6:00 P.M., except at DePere and Menasha, where hours are 8:00 A.M. to 12 midnight, trips through the Lower Fox River must be carefully planned to be completed in one day. With advance notice additional lockage time from 8:00 A.M. to 10:00 A.M., and from 6:00 P.M. to midnight, is allowed at Little Kaukauna, Rapide Croche, and Appleton locks, and for a similar evening period at the other locks. These restrictions cause some inconvenience to recreational boaters and require advance planning but are necessary to keep project operational costs to a minimum.

6.72
Currents Hindering Navigation - The Lower Fox River is the outlet from Lake Winnebago, which is the natural reservoir regulating the flood flow from the large drainage area of the Fox and Wolf Rivers above the lake. At times of maximum flood peaks the inflow may reach about 35,000 cubic feet per second, while the maximum outflow that can be released to the

Lower Fox River safely is about 23,000 cubic feet per second. To regulate Lake Winnebago within prescribed limits and avoid extensive flood damages, it may be necessary to release flows near the maximum capacity of the lower river for periods of a week or more. The average period of sluicing required to regulate Lake Winnebago within the prescribed limits is about 2.5 months per year. When the discharge from Lake Winnebago exceeds about 5,000 cubic feet per second the strong current in the Lower Fox River makes navigation difficult. The strong currents also are hazardous to recreational boating and there have been several past instances of small boats being carried through the sluiceways, in some cases with loss of lives. To prevent recurrence of this situation, it is necessary to almost wholly suspend boating on the Lower Fox River during flood periods.

6.73
Limited Navigation Season - The short navigation season on the Fox River is a limiting factor for recreational traffic. Ice conditions during the winter and early spring make it impractical to operate the locks, and also increase the costs of regulating the various pools and Lake Winnebago by operation of the sluice gates. The usual navigation season is from about 1 May to 1 November, or 185 days, and periods of heavy flood flows frequently shorten this by two to three weeks.

6.74
Power Operation of Lock Gates and Valves - The miter type gates of the present locks are operated by means of a hand powered capstan applying power to a small pinion which meshes with a gear rack on the gate spar. This is a slow operation, and with one lockman on duty if both miter gates must be opened requires that the lockman, after opening one miter gate, must walk to the opposite end of the lock to cross on the lock gates and return to open the second miter gate. The reverse procedure is necessary to close the gates. A similar operation must be repeated to open the gates at the opposite end of the lock. For safety it is not desirable to permit assistance by persons from the passing boats. Filling the locks is accomplished by operating butterfly valves in the valve platforms or upper locks walls by hand-powered handwheels operating a gear train to turn the valve. Fast filling requires opening each of six valves by a separate operation and this is a slow procedure with one man on duty. Valves for emptying the locks are located in the lower gates and each of the six butterfly valves is operated by a lever and pinion arrangement meshing with a gear rack on a vertical valve rod. Using this manually operated equipment the average time per lockage now is about 10 minutes and to pass boats in this time usually requires that the gates at the approach end of the lock be open in advance, and that the size of boats passing require only opening one gate for leaving the lock.

6.75
To expedite lockages and increase the capacity of the locks to handle expected traffic, it would be possible to provide for electrically powered operation of the gate and valve operating mechanisms. However, due to the sizable costs involved it is necessary to forego power operation of the locks until such time as it may become necessary to replacing existing locks with new ones.

6.76
Boat Lifts - Maintenance and operation of the locks will make it possible for increasing numbers of the larger boats in recreational use on the Great Lakes to cruise to, and in many cases make prolonged stays on, the attractive boating waters of the Lake Winnebago Pool and the Wolf River. Possible alternatives to permit the passage of recreational boats without the maintenance and operation of the locks were considered but were found to be generally unsafe and inadequate to handle the current and prospective traffic. Manual boat lifts operated by the users would be too slow for expected traffic and unsafe for handling of the larger boats by inexperienced personnel. Power lifts operated by trained employees would be slower and probably more costly to maintain and operate than the locks, and would require multiple units to handle the traffic at the busier locks. Replacement of existing locks with any type of marine railway would not be justified by any saving in costs, and would be less safe and slower. Substitution of lifts, railways, or other transfer facilities for the locks would destroy the desirable capability to handle occasional passages of dredging or construction equipment, barges with bulk cargoes or heavy machinery, or other waterborne commerce.

Dam Operation

6.77
A number of conflicts have arisen over the operation of the Winnebago Pool. Principally these relate to the effects of storage and release on upstream fish and wildlife and riparian interests and downstream industrial, municipal and hydropower uses. While change in the regulations of the Menasha Dam control to reduce the fluctuations of the Winnebago Pool water levels andreduce the mean level could improve the natural conditions in Lakes Poygan, Winneconne, and Butte des Morts, such changes could have severe adverse effects at times on downstream water quality and stream uses for industrial, municipal and hydropower uses. And in the case of hydroelectric power, the surplus water created by the dams and not needed for navigation is legally reserved by the power interests.

6.78
Lake Vegetation Management - Over the past several decades, high water and fluctuating water levels have been a primary factor in the continuing extensive losses of aquatic and semi-aquatic vegetation which has occurred in the upriver lakes region. The effects of high waters in destruction of marshes and floating bog have been readily and widely publicized during periods of major flooding. It seems to be the sudden periods of spring and summer flooding that have done the most damage to the vegetation by breaking up and flushing out the floating mat. The destructive effects of seasonally high water on the true aquatics are less obvious but may be equally severe.

6.79
In an effort to hold the line against further losses in vegetation, Arlyn Linde, aquatic resources specialist for the Wisconsin Department of Natural Resources, (Oshkosh Area Office), has suggested to the Corps that mean early and mid-summer water levels should be reduced about 6 inches. This would mean holding an average gage level of 2.3 feet (747.349 on the Oshkosh gage) for the summer months. Of course, since flow conditions fluctuate during the course of the summer, water levels would vary somewhat above and below this level. According to this proposal, levels should be maintained as closely as control capabilities will permit and every effort should be made to keep high summer flows from producing deep flooding, regardless of how temporary it is. Linde further proposes to increase the average spring drawdown by about 6 inches in hopes that it might reduce the amount of spring loss due to flood conditions by increasing the capacity of the pool to receive high flows without an excessive buildup in water levels. A copy of Mr. Linde's water level management recommendations is included in Appendix D of this statement.

6.80
The recommended 6-inch reduction in Winnebago Pool levels was developed on the basis of DNR examination of historical stage and flow rates for the lake over the period of record. Six inches represents the approximate mean summer water level increase that has occurred in Lake Winnebago over the past several decades.

6.81
Monthly water level averages have been used to construct a graph that illustrates long-term changes in Lake Winnebago water levels (Figure 6.1). From this figure it can be seen that the monthly mean levels during the April through October period have risen 4 to 7 inches in a comparison between the time periods 1896 - 1937 versus 1938 - 1976. To what extent this project-controlled lake level increase has promoted wetland losses in the upriver lake area is unknown. An increase of this size certainly could be expected, however, to bring about changes in vegetative cover.

6.82
A six inch drop in summer water levels would reduce the chance for floating bog to break loose and float out, and make protected marsh areas more secure by reducing the chance for high water and waves to top existing riprap installations. An additional winter drawdown of six inches is generally consistent with the present policy of gradual drawdown in the fall and winter months to provide full drawdown before the spring runoff occurs.

6.83
Low Flow Augmentation - The problems of water pollution control and dissolved oxygen in the Lower Fox River are very complex. Factors affecting the streams dissolved oxygen content are its volumetric flow rate, area, and depth; the initial quality of the water which enters it; the effluent loads which are placed upon it; the modifications due to existing dams or

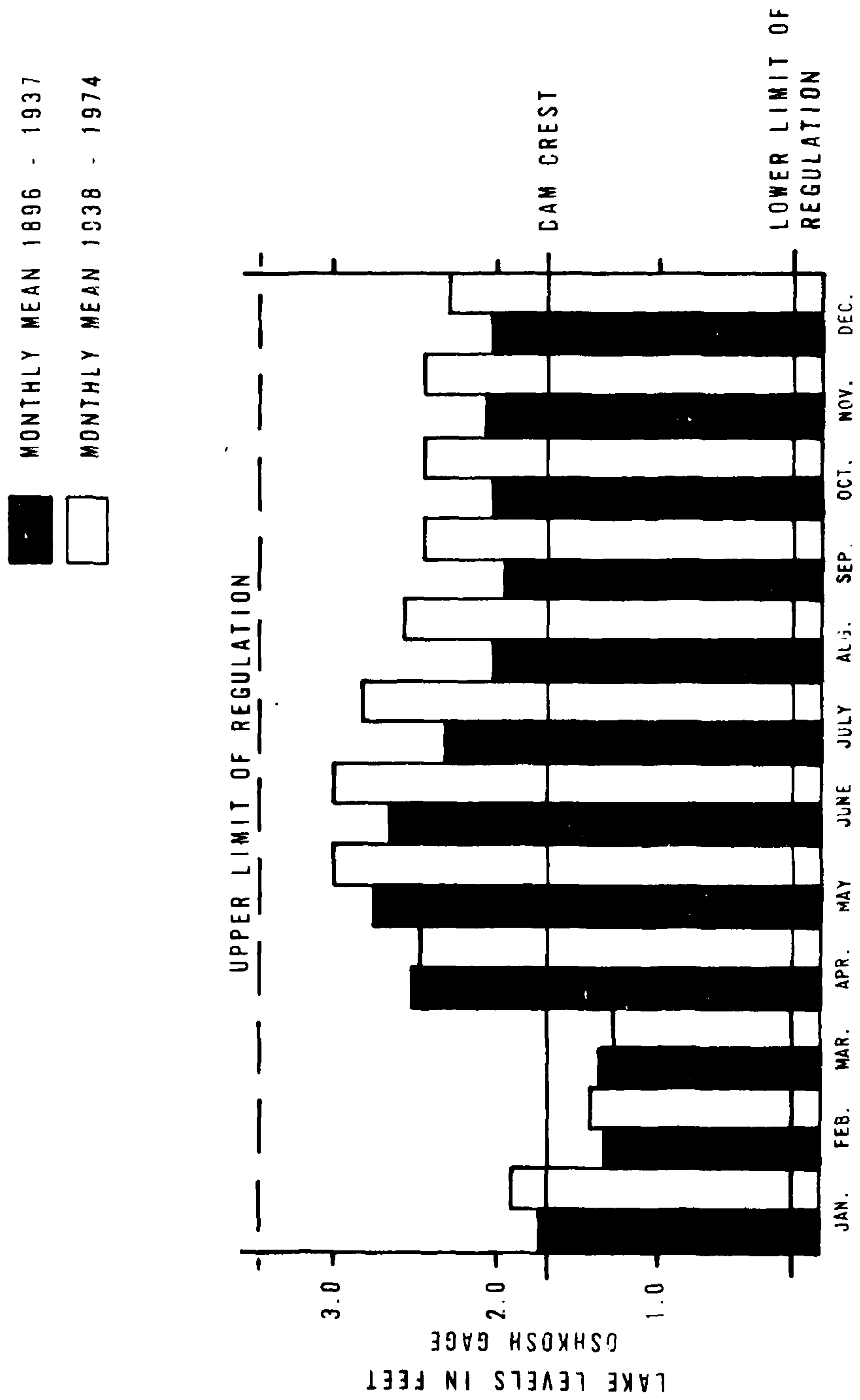


Fig. 6.7. Lake Winnebago at Oshkosh Lake Levels

other man-made facilities which exist; and the type and character of the sediments in the stream. These physical and chemical factors of the river in turn affect the entire biological system which obtains the river's suitability for private and public uses.

6.84
The Lower Fox River has been designated as a top priority stream requiring improvement in Water Quality by both the EPA and Wisconsin DNR. Solutions to the water pollution control problems on the Lower Fox River are very complex and will likely involve the development of a comprehensive regional water quality program for the river including, but not limited to, improved waste treatment, additional monitoring and enforcement actions, and possibly additional flow regulation.

6.85
Historically the water quality of the Lower Fox has been a problem since the installation of the lock and dam canal system constructed in the 1860's. During the low controlled flow of the warm summer months, low dissolved oxygen is a special problem. The dams are significant to dissolved oxygen because they produce wide, less turbulent pools and opportunity for the settling of suspended solids in the pools upstream of each dam. Thus the river now exists, throughout practically its entire length, as a series of comparatively slow-moving ponds rather than its former rushing rapids.

6.86
Water Quality is not as yet included as a major criterion in the operation of river and lake controls although the potential benefits of flow control on pollution were recognized by the Corps as far back as 1921. (House of Representatives Document 146). A possible alternative to the present operation, therefore, would be modification of the present dam operating rules which would include water quality as a criterion in addition to the long existent criteria of flood control and navigation established by the Marshall Order.

6.87
The process of organic degradation is common to all rivers. The death and decay of underwater plant and animal life constitutes stream pollution which is eliminated by the oxygen content of the water. Domestic and industrial wastes are eliminated by the same natural processes. The waste load becomes unduly burdensome on the Lower Fox River during the late summer and early fall. The problem will remain exceptionally difficult, if not insoluble, as long as the amount of available dissolved oxygen is limited by the reduction in water flow from Lake Winnebago during the late summer and early fall of each year.

6.88
In order to prevent stagnation and degradation of the water quali[illegible] the Lower Fox River, it may be necessary to augment [illegible] leases from the project control dams at Neen[illegible] and [illegible] of the latest stream standard is questiona[illegible] as recognized by the State DNR and [illegible]a.

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consensus among water quality experts that in addition to current pollution control efforts by industry and municipalities, it may be necessary to update the basic plan for operation and use of the water available in the Winnebago Pool to include the maximum storage and use of the available water for the purposes of low flow augmentation.

6.89
Any program for maximizing use of Lake Winnebago waters for best public benefit must take into consideration the total volume available in the Fox-Wolf watershed. The total drainage area served by the Fox, Wolf and Lake Winnebago encompasses 6,150 square miles with the Lake Winnebago Pool covering 265 square miles. Of major significance is the fact that one inch of depth on the Winnebago Pool is equal to 7,125 cubic feet per second per day. The capacity of the Lake Winnebago Pool, within the legal limits of the Marshall Order which range from a high limit of 21-1/4" to a low of minus 18", a 39-1/4" permissible differential, is equivalent to 280,000 c.f.s./day flow, excluding any part of the normal inflow from the Wolf and Upper Fox. For example, the reservoir's capacity, exclusive of variables such as evaporation, etc. could theoretically provide low flow augmentation to the extent of 3,000 c.f.s. for a period of 90 days, which, when added to the selected low flow of 912 c.f.s. or the annual average flow of 4,000 c.f.s would have a major effect on Dissolved Oxygen in the Lower Fox during the historical low flow summer months. One half of this amount would have significant influence. The beneficial net effect of flow volume has been readily evidenced by results obtained from Federal and State stream modelling studies.

6.90
Such use of storage at Federal projects is contemplated by the Federal Water Pollution Control Act, as amended in 1961 by Public Law 87-88. Section 2b of the amended act provides that "in the survey or planning of any reservoir by the Corps of Engineers, ***consideration shall be given to inclusion of storage for regulation of streamflow for the purpose of water quality control, except that any such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling waste at the source." The need, value and impact of storage for water quality control is determined by the Administrator of EPA. The act does not authorize modification of completed projects to include water quality control, but does indicate that water quality control is to be considered a legitimate purpose of a project along with other beneficial uses of the water. Since measures that affect public health and welfare are subject to regulation by appropriate public agencies, the procedures for regulation and use of the storage capacity of Lake Winnebago could be changed if required to improve water quality and reduce health hazards. The indirect benefits to public health from improved water quality cannot be evaluated. Public Law 92-500, 18 October 1972, relating to Comprehensive Programs for Water Quality Improvement, specifically describes how the Corps, or other federal agency, can participate in projects of this nature.

6.91
Other water quality improvement alternatives to be considered as means of helping to achieve regional water quality goals and standards are:

- More stringent effluent treatment requirements for industry and municipalities.
- Hydro-turbine air venting to replace dissolved oxygen generation lost by lock and dam construction.
- In-stream mechanical aeration at dissolved oxygen sag points in the river.
- Release of flow over spillways, rather than through dam gates, valves and turbines to extent practicable.
- Control of algae production in the Lake Winnebago pondage.
- Reduced hydro-power generation to allow more flow to pass over the dam spillways.
- New treatment plant site selection based on optimum discharge point locations in relation to river assimilative capacity.

Enhancing Project Recreational and Conservation Features

6.92
Completion of the Neenah and Wolf River channels, full maintenance of all channels, and improvement of the locks to expedite the movement of boats and avoid interruption of boating by lock failures would likely increase the amount of recreational boating in project waters. By physically improving the project for recreational navigation, sport fishing and other activities would also benefit.

6.93
The Project has a recreation potential of somewhat unique character in that the river provides opportunities for a continuous recreational waterway with satisfactorily spaced access and development sites. While this potential does not appear to have national or regional significance, it is of sectional and local importance.

6.94
While none of the existing tracts of Federally-owned land in the project are suited for conversion to public recreational development and use, development of recreational facilities on newly acquired lands throughout the project area and the creation and/or expansion of small craft harbors and mooring areas within the municipalities along the Lower Fox would be possible. Improvements could be planned and designed to enhance the existing recreational resource potential in the project area and provide increased accessibility to scenic areas along the waterway. Improvements could also be designed to correct other present waterway deficiencies and enhance environmental values (such as creation of marshland).

6.95
The impacts of any of the above actions, including the bank erosion and water turbidity caused by increased boating, would have to be thoroughly studied prior to the implementation of any project modification.

SECTION 7

RELATIONSHIP BETWEEN THE LOCAL SHORT-TERM USE OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

GENERAL

7.01
Relationships between operation and maintenance activities are considered in the short run, and their long-term effects have been identified in several areas. The direct effects of dredging are not expected to substantially alter aquatic, terrestrial, and semi-aquatic habitats or to greatly change the distribution of species or lead to their extinction. The short-term use of the Lower Fox River and Wolf River (including the Winnebago Pool) as a recreational waterway will continue to provide economic benefits to the area on a seasonal basis.

WATER QUALITY

7.02
In the process of dredging sediments from the project area certain water-quality effects will be evident. During dredging, the turbidity created will detract from the general water quality. Pollutants adsorbed on the sediments could potentially be reintroduced into the aquatic system during the dredging operation. The exact degree of pollutant reintroduction and the nature of the associated impacts are not sufficiently understood at this time. As the dredging is completed and the sediment-water interface stabilizes, the waters associated with the project will improve. This will be accomplished by the removal of polluted materials within the bottom sediments.

AQUATIC HABITAT

7.03
Operation of the Neenah and Menasha dams and maintenance of the navigation channel from Lake Winnebago to the Wolf and Upper Fox Rivers over the past century have, in part, led to wetland losses and an increase in open-water habitat in the Winnebago Pool and the Wolf River. The lakes in the lower Wolf River area include White Lake, Partridge, Partridge Crop, Poygan, Winneconne and Butte des Morts. These lakes, along with the Wolf River and its tributaries in this area, serve as spawning grounds for numerous fish species and are a subflyway of the Mississippi flyway. Conflicts between boating activities and fish and game interests are common in this area, particularly on the lakes and rivers south of New London.

7.04
The adverse effects of dredging upon the total biota are generally temporary in nature. The benthic community, even though destroyed by

dredging, will gradually become recolonized and grow until such time as additional dredging is performed. The short-term effects of occasional turbidity also are temporary in nature.

7.05
Many aquatic species are no longer present in the Lower Fox River. To the extent that water quality has been degraded by navigation and by operation and maintenance activities on the waterway, project activities may serve to continue to limit the distribution of these species.

7.06
Because of wetlands losses in the Winnebago Pool and the Wolf River, the productivity of important game fish and panfish species has probably been reduced within the project waters. The exact nature and the extent of this impact and the relevant importance of each of the possible contributing causes summarized in this report require more detailed study. To the extent that current flow regulation practices contribute to these environmental problems, this productivity will probably continue to decrease. Removal of material during dredging operations physically displaces benthic organisms and their immediate habitat.

SEMI-AQUATIC AND TERRESTRIAL HABITAT--BIOTA

7.07
The deposition of dredged materials in any area reduces, at least initially, the carrying capacity of the flora and fauna of the area. Adverse biotic effects on the semi-aquatic sector will persist due to the fluctuating water levels that result from dam operation. The periodic dredging in the Wolf River and Winnebago Pool will repeatedly destroy some submergent and emergent vegetation. Erosion from waves generated by the various types of powerboats will adversely affect shorelines and their associated emergent vegetation.

ECONOMICS--LAND USE

7.08
Since the abandonment of the Lower Fox River as a commercial shipping waterway in 1959, the waterway has served almost exclusively as a navigation route for recreational craft. Consequently, land-use changes along the waterway are little influenced by the presence of the existing navigation system.

7.09
Dredging activities may eventually have an effect on local crop production. Farmers in the vicinity of Brothertown, Stockbridge, and Calumet Harbors have used dredged materials as fill in low-lying areas of agricultural fields in order to increase productivity. Once normal soil stratification and porosity are attained, these fill areas are expected to become more productive.

7.10
The adverse effects of fluctuating water levels on the marsh vegetation in Lakes Butte des Morts, Poygan, and Winneconne could continue to remove marsh habitat and thereby reduce the conservation and use values of the existing marshes.

WATERWAY USE

7.11
It is clear that discontinuance of maintenance of the existing navigation system would result in serious short- and long-term economic and social impacts. Nevertheless, in the long run, the best use of the river can only be determined by more thorough evaluation of the costs and benefits (environmental, economic and social) of alternative project futures within the context of basin land and water resource management problems and needs. In this regard, there are certain comprehensive investigations now underway which may be expected to have great bearing on future project purposes, features, and management. Notwithstanding the outcome of these studies, it is our view that, for the present, the Fox River Navigation Project should be operated and maintained in the manner proposed herein.

SECTION 8

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

GENERAL

8.01
Several areas of resource commitment have been identified in preceding sections. Major concerns include aquatic habitat losses and associated fishery decline, and allocation of Federal funds for a lock system currently used almost exclusively for recreational navigation purposes and the costs of which might be more appropriately assigned to the State of Wisconsin or users of the facilities.

SEDIMENT AND BENTHOS

8.02
Dredging will remove sediment obstructing the waterway and eliminate some organisms inhabiting the waterway. It is estimated that the action will irrevocably remove about 400,000 cubic yards of dredge materials from river and lake environments within the project over the next ten years. The restrictions on the growth of benthic organisms caused by the polluted sediments, along with the expected new population of the dredged area, diminishes the severity of this adverse effect.

AQUATIC HABITAT AND BIOTA

8.03
It is possible that lock and dam structures have acted as a physical barrier to the movement of some aquatic organisms between pools, thus affecting their distribution. Continued regulation of the Winnebago Pool water levels under present operating procedures could also, via possible additional wetland losses, promote further loss of spawning habitat, refuges, and food resources for the adults and young of various fish species, such aswalleye and yellow perch. This in turn could adversely impact upon the recreational and economic fishery resources of the State of Wisconsin.

8.04
As a result of the increased rough fish productivity on the Wolf and other rivers throughout the state, the State of Wisconsin is expending money to control rough fish populations and improve the productivity of the more desirable game fish and panfish species. This commitment of resources is attributable in part to those project activities which are believed to promote rough fish productivity.

SEMI-AQUATIC HABITAT

8.05
Fluctuating water levels in Lakes Butte des Morts, Winneconne, and Poygan caused by operation of the Neenah and Menasha dams have promoted loss of

marshlands in these lakes. Marshes serve as areas for breeding, foraging, and cover for many wildlife species. Consequently, the reduction in marsh vegetation has significantly reduced the carrying capacity of the area for various wildlife species.

TERRESTRIAL HABITAT

8.06
The deposition of highly polluted dredged materials can eliminate varying amounts of terrestrial habitat. The amount eliminated will depend upon the quantity and quality of dredged materials deposited. If the chemical and physical nature of these materials is similar to the existing substrate, and no significant topographical changes are created as a result of the deposition, succession will likely restore the vegetative community to its original state after three to five years. Otherwise, vegetative reestablishment would occur more slowly and long-term permanent alterations could occur. The magnitude and direction of such changes will depend upon the specifics of the given situation.

LAND-USE COMMITMENTS AND RESTRICTIONS

8.07
The deposition of dredged materials on a given site may alter its potential future uses. Disposal of sand and gravel could alter the future substrate in such a manner as to make it unsuitable for certain agricultural and other uses.

8.08
Lands committed to serve waterway and navigation functions are not available for alternative uses.

ENERGY CONSUMPTION COMMITMENTS

8.09
The energy expended for the operation and maintenance activities of the project is lost and cannot be regained. These losses are considered to be very small, however.

ENERGY COMMITMENTS

8.10
Labor and materials which would be committed to the project represent an irretrievable action. Continuation of the project will result in the short-term annual expenditure of about $1 million. The dollar value of this commitment is expected to grow over time with the annual inflation rate. The amount used is offset by the benefits that would be derived by both current and future generations.

SECTION 9

COORDINATION AND COMMENT AND RESPONSE

PUBLIC PARTICIPATION

Agency and Community Contacts

9.01

This statement reflects extensive coordination and contact with personnel of other Federal, State, and local agencies and the general public. No public meetings were held for the specific purpose of securing for this report from local interests as their opinions and desires are generally well known through operation of the existing project and comments on previous reports pertaining to the project and its operation.

Agency Review

9.02

A draft environmental impact statement was submitted to Federal, State, and local agencies, other interested organizations, and made available to the public for review and comment on 15 December 1975. A listing of the recipients of the draft statement is presented in the forward section of this document immediately following the Summary statement. A list of those responding is included in paragraph 5 of the Summary. Copies of the letters commenting on the draft statement, and responses to those comments, are reproduced in comment/response portion of this section.

Unresolved Issues

9.03

State objections concerning inlake disposal of unpolluted dredged materials still remain unresolved. The Wisconsin DNR has requested that the dredged material taken from the Boom Cut, Wolf River, entry to Lake Poygan and the Big Lake Butte des Morts channel below the junction of the Upper Fox and Wolf Rivers be disposed of on surrounding upland areas. In lieu of land disposal, the Chicago District has recommended that unpolluted dredgings from these locations be used to reestablish, protect, and enhance local wetland and marsh habitat.

9.04

It is the policy of the Corps to secure the maximum practicable benefits through the utilization of materials dredged from authorized navigation channels and harbors, provided extra cost to the Government is not incurred. Such use of dredged materials includes nourishment of beaches, erosion control of river banks, land reclamation and marsh construction. If it is evident during the initial planning of dredging operations that additional costs would be incurred, local interests

are given reasonable opportunity to finance the additional costs. In the specific case of the design and construction of diked disposal facilities for the confinement of polluted dredgings, local cost participation is usually not required.

9.05

With the cooperation and assistance of the U. S. Fish and Wildlife Service, the Wisconsin DNR and the U. S. Environmental Protection Agency, a dredged material disposal plan has been developed. This plan, with the notable exception of dredging and disposal at Boom Cut, meets the short-term disposal requirements for the project. In the absence of any indication by the State of a willingness to assume the additional costs of upland disposal at this location, the Chicago District will suspend Boom-Cut dredging operations indefinitely. Extensive recreational boating use of much of the Wolf River segment of the project is made possible by maintenance of this cut-off channel. The dredging of Boom Cut eliminated a tortuous route in the upper reaches of Lake Poygan for recreational boating. This short cut reduced the cruising distance about 5 miles in this reach of river. It has been reported that sedimentation in the shoal water of Lake Poygan has reduced navigation depths to two feet or less along much of the Boom Cut reach.

9.06

Due to the nature of the present, unresolved conflict with the Wisconsin Department of Natural Resources concerning inlake disposal activities in the upriver lakes region, the Chicago District has recommended special investigation and research into the development and evaluation of the feasibility, methods and criteria for protecting and establishing wetland and marsh habitat. It is hoped that this type of research effort will lead to the development of an operational and environmentally satisfactory plan of inlake disposal which is acceptable to the State of Wisconsin.

COMMENTS AND RESPONSES

General Remarks

9.07

In December 1975 the Chicago District issued a Draft Environmental Impact Statement (DEIS) relating to the operation and maintenance of the Fox River, Wisconsin Navigation Project. The statement provided an objective assessment of the environmental impacts associated with the operation and maintenance of the existing Federal project. Preparation and subsequent coordination of the DEIS with other agencies, organizations and the general public identified several areas of major regional resource management concerns in the Fox River Basin which included: aquatic habitat losses and associated fish and wildlife declines; continued allocation of Federal funds for a lock system now

used almost exclusively for recreational rather than commercial navigation, the authorized project purpose; the impact, need, and justification for periodic dredging and dredged material disposal requirements; and water quality degradation along the Lower Fox River. In addition, questions were raised as to whether or not there was a continuing Federal interest in the operation and maintenance of the existing project, including whether the project was responsive to current regional and local water resource needs, or if a change in Congressionally authorized purposes and project features would be in the overall public interest.

9.08

While continued project operation and maintenance is related to each of these issues to some degree, resolution of these resource management issues is in many instances beyond either the ability or the authority of the District to resolve within the scope of this environmental assessment. Some of the basic factors relating to this problem are that the project is being operated consistent with existing Congressional authorizations although the needs and concerns within the basin are changing; that hydropower rights in law and existing lock and dam features impose constraints on project operational management; that substantive changes to present project purposes features and/or operational procedures would require Congressional authorization and approval; that a comprehensive, detailed benefit-cost evaluation of the project and a full range of alternatives would be needed to determine whether the existing project and operation are optimized; and that, based on present knowledge, it is impossible to ascertain the extent to which non-project induced interactions and interrelationships also contribute to identified regional resource management problems. The proposed action described in this final statement does not recommend any major change in the purposes, features, or operation of the Fox project at this time. Any such proposal would require considerably more detailed research and investigation and Congressional authorization.

9.09

The basic project-related resource questions, relationships and conditions which should be further studied, are summarized in the following paragraphs.

9.10

Need for Dredging - Dredging is periodically accomplished at various times to maintain adequate channel depths. Additional study and analysis is required to evaluate the economic feasibility of the continuing channel maintenance required to support recreational boating, however. An analysis of the economics of continued project operation and maintenance will be completed in FY 1978. The results of this analysis will be summarized in a future addendum to this impact statement.

9.11

Flow Augmentation - The existing operational procedure relating to flows regulated within the authorized project should be reevaluated. Periods of inadequate flows accentuate water quality problems on the Lower Fox River. It is recognized that flow augmentation for water quality purposes is not a suitable substitute for compliance with Federal and state water quality standards and adequate treatment or other methods of controlling waste at the source. However, Federal and state water quality studies have shown that maintenance of a higher minimum base flow may be desirable. An enhanced base flow may also benefit instream recreation and fishery enhancement. Since the current operation of the Fox River project has a substantial effect on the hydrology of the Fox River system and hence its water quality, more information and detailed studies are needed to assess the effects of project operation, including power generation, on water quality. Proposals for changes to current flow regulation procedures should reflect studies and recommendations made by the Wisconsin Department of Natural Resources and the Fox Valley Water Quality Planning Agency (Section 208, PL 92-500, planning agency).

9.12

Water Level Management - The data presented in this FEIS suggests that water level control is the most important resource management issue associated with the current project operation. Regulation of the Winnebago Pool is believed to affect natural habitats within Lake Winnebago and upriver lakes by contributing to high summer pool levels and fluctuating water stage and contributing to floating bog and rooted emergent cover losses. Water level management also affects aspects other than vegetation, such as fish and wildlife resource values, shore and erosion and aesthetics, public access and lake utility and recreational boating. The interrelationships are complex and often conflicting and the management problems are great. Current water level management procedures tend to benefit the recreational boater and shore property owner, as well as the power companies possibly at the expense of fish and wildlife habitat and other conservation values. There will continue to be conflicts between water use and users along the Fox River system. Submergent vegetation is desirable for waterfowl feeding areas and with some restrictions it is of value to fish, but it is not welcomed by boaters, water skiers and swimmers. Emergent cover plants are essential for all forms of wildlife, but boaters would like to see more acres of open water and cottage owners generally do not approve of emergent vegetation growing in front of their cottages. Industry, which is dependent on water for power and for stream sanitation, would like to see ever increasing pool levels.

9.13

An equitable balance of these resource management needs and conflicts can only be developed by adopting a much broader approach to water manage-

ment than has occurred in the past. It will be necessary to fully take into account the effects of each water use on other water uses, and of upstream water uses on downstream uses. Long-term needs, as well as short-term requirements will have to be considered in the decision-making. Adoption of such an approach may require some important modifications to existing project features, policies, laws, and administrative arrangements, and the adoption of new criteria in the deicison-making process. Adoption of an overall approach to water management also focuses attention on the need for greater coordination of resource development and management efforts within and between the various levels of government. Because responsibilities relating to the management of the region's water resources are divided among many agencies at various governmental levels, there is a need for increased cooperation and coordination in dealing with water matters. The management technique that would be in the best interest of the most concerned is not now known. The unknown factors involved are so numerous that no single agency could provide the best answers.

9.14

The various conflicts and problems of water management in the region are neither simple nor isolated. Although the region has a great variety and abundance of water resources, the demand for these resources, is very substantial and continuously increasing. Some of the present and future demands for water are compatible, but others conflict. As a demand on the water resource continues to increase, conflicts of interest will be come greater and more widespread. Given the multiple use demands placed on a finite water resource, some conflicts are inevitable. The maximum advantage to any interest must be compromised for the achievement of an overall management plan.

9.15

While a number of water resource management problems exist in the Fox River region which require solution, it is not the purpose of this EIS to "resolve" these and other regional water use management problems. It is also not the purpose of this statement to determine whether or not project features and operation and maintenance activities are optimized in an economic sense. Rather, the purpose of this statement is to identify the nature and extent of the environmental impacts attributable to the operation and maintenance of the Fox Project.

9.16

Comprehensive land and water use management questions for the Fox-Wolf River Basin system , however, will be studied under the authority of the Fox-Wolf River Level B Study and the Section 208 regional water quality planning program. The Level B study will result in the formulation of a coordinated plan and alternatives for solving the major problems and issues of water and related land resources planning. It will provide for full consideration in planning for the optimum use, conservation, and/or development of these resources. The Section 208

Study will prepare an area-wide water quality management plan.

9.17

It is the view of the Chicago District that the resource management problems and conflicts relating to the Fox River project should be examined within the context of the ongoing Section 208 and Level B studies, and that further detailed investigation of the Fox River project not be undertaken until after completion of these studies. Proper water management involves the detailed analysis of the whole range of alternative use possibilities and the consequent effects associated with any given management plan. The Section 208 and Level B studies will provide the formal machinery needed to properly weigh competing claims between various water uses, to assess the relative values involved, and to insure equitable utilization of the water resource. The Section 208 and Level B studies should give direction to a management program that will realize the maximum capabilities of the region in all phases of water and related land use. The Chicago District will then be in a better position to reevaluate the Fox River project within the context of current regional needs, goals, priorities, and the overall public interest after the completion of these studies. The approach has the advantage of allowing the District to defer resolution of those issues which are beyond the scope of the existing Federal project operation and this environmental statement. The Federal EPA, the U. S. Fish and Wildlife Service and the Wisconsin DNR have indicated support for this approach.

9-7

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THE STATE HISTORICAL SOCIETY OF WISCONSIN

816 STATE STREET / MADISON, WISCONSIN 53706 / JAMES MORTON SMITH, DIRECTOR

State Historic Preservation Office

December 24, 1975

Colonel James M. Miller, District Engineer
Chicago District, Corps of Engineers
219 South Dearborn Street
Chicago, Illinois 60604

SHSW 0172-75-1

Dear Colonel Miller:

This is in reply to your December 15 letter concerning the draft environmental statement (DES) relating to the operation and maintenance of the Fox River, Wisconsin Navigation Project.

This office concurs in those matters set forth in the DES concerning archeological and historical preservation.

We look forward to working with your office in making the archeological surveys and assessments outlined in Section 2.115 of the DES.

Sincerely,

James Morton Smith
State Historic Preservation Officer

JMS:owmc

cc: Mrs. Dorothy Wittig, Research Chairman
Brown County Historical Society

Mr. Donald Blakely, President
Fond du Lac County Historical Society

Mrs. Alice DuBois, Secretary
Neenah Historical Society

Mr. Dean W. Sandeman, President
Winnebago County History & Archeological Society

Mr. Robert W. Lutz, President
Calumet County Historical Society

Mr. Douglas Strong, President
Menasha Historical Society

Mrs. John Kellog, President
Outagamie County Historical Society

Mrs. Loren Driscoll, President
Winneconne Historical Society

The results of the requested surveys and assessments were subsequently furnished the State Historical Society of Wisconsin. By letter dated 19 November 1976 (See Figure 2.14), the State Historic Preservation Officer concurred in the study finding that the proposed action would not impact on historical or archeological resources.

NEENAH

J.J. KRAUS, DIRECTOR OF ADMINISTRATION
PHONE 722-6427 AREA CODE 414

January 8, 1976

Department of the Army
Chicago District, Corps of Engineers
219 S. Dearborn Street
Chicago, Illinois 60604

NCCPD-ER

Dear Sirs:

The Neenah Harbor Commissioners, City of Neenah, Wisconsin, as the delegated regulating body for the Neenah Harbor, would like to make the following recommendations on the Draft of the Environmental Statement "Operation and Maintenance of the Fox River, Wisconsin, Navigation Project".

1. The Commission strongly supports the continuation of Federal operation and maintenance of the Fox River Navigation Project. It is the felt opinion that it would be a major loss to the boaters, businesses, communities and general public of the Fox River area if free access and movement from Green Bay to the upper reaches of the Fox River were to be lost by closing down the lock system.

Comment noted. The Chicago District recognizes the importance of the Federal lock system to boaters, businesses, communities and the general public in the Fox River area.

2. The Commission desires the entire Navigation Project completed as it was originally intended, but with local variations of the Project adjusted to meet the current needs of recreational boating.

The Federal project for Neenah Channel was originally authorized for commercial navigation. In 1929 before construction was started, local interests in Neenah indicated that the Neenah Channel was no longer required. As a result, this portion of the authorized project was placed in an inactive status. The Chief of Engineers has indicated that it would not be appropriate to reactivate and construct the authorized Neenah Channel improvement in the interest of recreational navigation since the project was originally authorized for commercial navigation. The Chief of Engineers has suggested that the improvement now desired by local interests could possibly be authorized as a new project under the authority of Section 107 of the 1960 River and Harbor Act, as amended. Section 107 authorizes the Chief of Engineers to investigate, adopt and construct small navigation projects. Upon receipt of a request for a Section 107 study, the Chicago District would initiate a preliminary investigation as soon as the District's workload permitted.

3. The Commission strongly supports the suggestions made on Page 6-8, Section 6.24, 6.25 for Project improvement to enhance recreational and conservation features. Consequently, it would like to learn if this report will cover the environmental impact of these future improvements.

See response to previous comment. The environmental impact of any alternative plan to further modify, develop, or enhance the recreational and conservation features of the existing project would depend on the specific plan of improvement to be recommended. No such modification is proposed at this time. A separate environmental impact assessment/statement will be prepared for any modifications which might be considered in the future.

4. The Commission is now actively trying to have the natural Neenah Harbor of refuge activated so that it could be included in the current Project work, particularly for dredging and maintenance. The Neenah City Council in July 1968 approved moving the privately dug navigation channel along Riverside Park to the center of the harbor as is shown in the attached map. In addition, in June 197-

Comment noted. See response to Neenah Harbor Commission Comment 2.

the U. S. Coast Guard agreed to the designation of a special anchorage area located along Riverside Park and Wisconsin Avenue, also shown in the attached map. Further plans are now under development.

5. It is the opinion of the Commission that development of Neenah as a small craft harbor, should be included in your recommendation in Section 6.24 or 6.25. The work would fall into two categories: dredging of sludge and soft fill which has silted in over the years, and widening and deepening of a navigation channel, but not at the location designated on A-16. It it hoped that your draft will include the work.

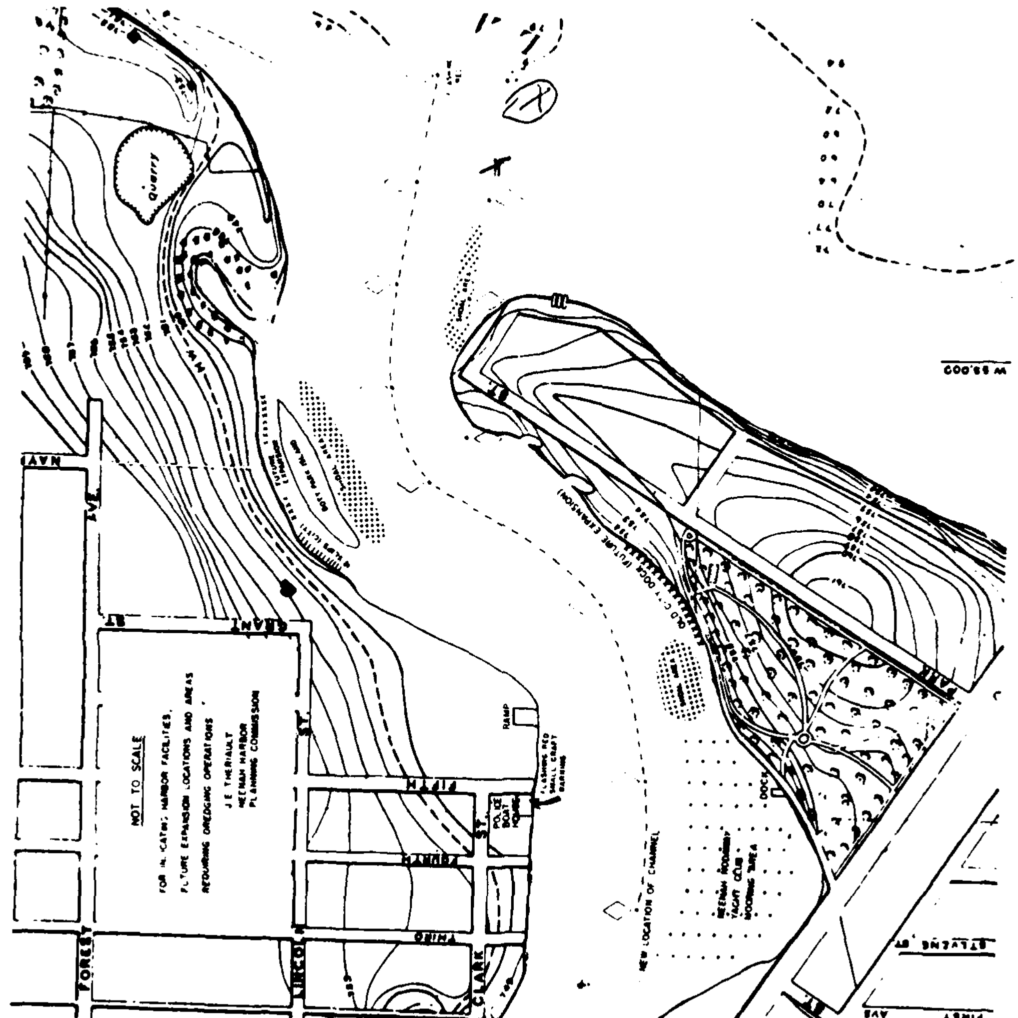
6. The Commission wishes to commend the Corps of Engineers for the excellent document you prepared, and it basically agrees with all your recommendations and conclusions.

Yours truly,

NEENAH HARBOR COMMISSION

Fred Oskar
Vice-President

See responses to Neenah Harbor Commission Comments 2 and 3. The primary purpose of this statement to discuss the environmental impacts associated with the operational and maintenance aspects of existing project features and activities.



Enclosure to City of Neenah Wisconsin Letter

State of Wisconsin \ DEPARTMENT OF LOCAL AFFAIRS & DEVELOPMENT

DIVISION OF STATE LOCAL AFFAIRS
BUREAU OF REGIONAL PLANNING & COMMUNITY ASSISTANCE

February 2, 1976

Colonel James M. Miller
District Engineer
Chicago District, Corp of Engineers
219 South Dearborn Street
Chicago, Illinois 60604

Dear Colonel Miller:

We have reviewed the draft environmental statement relating to the operation and maintenance of the Fox River Wisconsin Navigation project and have found it to be very thorough and have no comments on the proposed course of action. However, it is hard to determine why a report of this nature needs data, for example, on statewide mineral extractions (page 2-43); employment by industry, workers and wages (Table 2-19); and snowmobiles (page 2-93); as well as being massively developed in subject material. We feel that future reports should be briefer and more selective in the data they use and could do so without detracting from their substance.

Concur. The draft statement has been extensively revised in an effort to produce a more concise, readable final document. Data not pertinent to the analysis of either the project or its alternatives has been deleted from the final statement.

Please remove the Bureau of Local and Regional Planning from your mailing list as that agency is part of the Department of Local Affairs and Development and change the address to the Secretary rather than the Director of that Department.

Our mailing list has been revised.

Thank you for the opportunity to comment.

Sincerely,

Marc Williamson

Marc Williamson
Environmental Coordinator

MC:sp
2-169

CALUMET COUNTY PLANNING DEPARTMENT

[illegible]
Planning Director
DuWayne Klessig
Code Administrator
Robert B. [illegible]
County Surveyor

[illegible] Court Street
Chilton, Wisconsin [illegible]
Phone: [illegible] Ext. [illegible]

February 2, 1976

Mr. Ross Plainse
Project Engineer - Army Corp of Engin.
905 South Oneida Street
Appleton, Wisconsin 54911

Dear Mr. Plainse:

After reviewing the "Draft Environmental Statement relating to the Operation and Maintenance of the Fox River, Wisconsin Navigation Project," this office is forwarding the following comments:

1. Table 1.3 indicates the location of proposed disposal areas but many are much too general to pinpoint. This office would be interested in the exact disposal areas for especially Brothertown Harbor and Stockbridge Harbor.

2. Section 1.20 Maintenance Dredging - and Section 4.76 both discuss disposal of dredge material. An objective of dredge material disposal is to prevent run-off to waterways or groundwater contamination, yet many of the disposal sites appear unsuitable to meet this objective.

3. Section 4.07 discusses the effects of dredging on the aquatic biota. The statement is made "any losses due to dredging would probably be short-term ones." I would question this statement unless some detailed studies would prove otherwise.

4. Section 4.11 indicates that dredging on the Wolf River during late summer would have relatively minor impacts on fish populations. This would be questionable especially during low-flow periods.

5. Section 4.10 states that dredging of sites with toxic substances is not desirable. It goes on to say "that duration of the impact will be short, however, and no significant adverse effects are expected." Again that statement would be questionable unless research proves otherwise.

6. After reading Section 6.0 of the report, it appears it is no longer economical to provide a lock system. The small number of recreational craft that used the lock system at a cost of more than $300,000 warrants further investigation on possible abandonment.

I trust that public hearing(s) will be held on this report. Please advise this office of such.

Sincerely,

DuWayne Klessig
Code Administrator

DK/pw

The locations of proposed disposal sites for Brotherton and Stockbridge Harbors are shown in Figures 1.14 and 1.13, respectively. The plan of disposal for these harbors features the temporary storage of dredged materials on existing Federal properties prior to ultimate disposal on agricultural lands.

Additional information pertaining to the engineering plans and the details of approved disposal sites is contained in this statement. Leaching and runoff are not anticipated to be a problem for the reasons stated in paragraphs 4.75-4.76 and 4.110-4.115.

Detailed discussion and documentation of the short term effects of dredging on aquatic biota is contained in Sections 4.33 - 4.53 of this statement.

Although the amount of dissolved oxygen in the Wolf River waters is lowest in late summer and may drop as low as 4.2 ppm at Freemont during the periods of low river flow, the environmental stress on Wolf River fish populations is nevertheless rather minor at this time because the amount of oxygen demanding material in the sediments is low and spawning, hatching, and larval development has ceased for most fish species.

The statement has been revised to clarify that dredging of sites with toxic substances will not in itself affect any substantial long-term ecological degradation. The effects of strong winds and currents with accompanying sediment resuspension normally dwarf the environmental impacts resulting from biochemical interactions between sediments resuspended during dredging and the surrounding aquatic environment.

A detailed investigation pertaining to the possible abandonment of the Federal lock system is beyond the scope of the current environmental impact study and no such study is planned at the present time. Any further detailed investigation relating to the status of the Fox River Federal project would not be undertaken until completion of the proposed multi-agency, Level B study of the Fox-Wolf Basin. The major purpose of the Level B study is to determine the desires and needs of people within the region for conservation, development and utilization of water and related land resources, and to identify and recommend action plans and programs to be pursued by Federal, State and local agencies. At the completion of the Level B study, the Chicago District may be in a better position to reevaluate the Fox Project within the context of overall regional needs and the public interest.

The Chicago District does not plan to hold a public hearing on this particular report. It is our view that the Federal project is being operated consistent with the existing project authorization, that the purpose of this statement is to describe the environmental impacts relating to continued operation and maintenance of the project and that the opinions and desires of local interests are well known through previous comments relating to operation of the existing project.

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230

February 3, 1976

Colonel James M. Miller
District Engineer
Corps of Engineers
Department of the Army
219 South Dearborn Street
Chicago, Illinois 60604

Dear Colonel Miller:

This is in reference to your draft environmental impact statement entitled "Operation and Maintenance of the Fox River, Wisconsin Navigation Project." The enclosed comments from the National Oceanic and Atmospheric Administration are forwarded for your consideration.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving eight copies of the final statement.

Sincerely,

Sidney R. Galler
Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

Enclosure: Memo from NOAA - Great Lakes Environmental Research Laboratory

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
Great Lakes Environmental Research Laboratory
2300 Washtenaw Avenue
Ann Arbor, Michigan 48104

JAN 29 1976

January 23, 1976

TO : Director
Office of Ecology and Environmental Conservation, EE

FROM : Eugene J. Aubert
Director, GLERL

SUBJECT: DEIS 7512.41 - Operation and Maintenance of the Fox River, Wisconsin Navigation Project

The subject DEIS prepared by the Corps of Engineers, Chicago District, on environmental impacts of operation of Fox River navigation project has been reviewed and comments herewith submitted.

The rules governing the water levels and flows in the navigation system on the Fox and Wolf Rivers, Wisconsin, have been established in 1886 and last modified in 1920. Nutrient and organic input to the Lower Fox River is so great at times that dissolved oxygen concentrations decrease to nearly zero, especially during the summer months, making this water unfit for most organisms (Paragraph 2.199). The Statement recognizes that additional water release from upstream would alleviate these undesirable conditions; however, regulations and other interests prohibit such activities except in extreme situations (Paragraph 4.70). It concludes that since present procedures are predicated on obtaining the best balance between varying water use interests within existing laws while attempting to insure navigation and to predict upstream weather, no meaningful alternative for the present operation appears to be feasible (Paragraph 4.100).

As stated, the last modification of waterway operation rules was in 1920. Since that time, commercial navigation ceased on the water in 1959 and significant progress has been made in environmental understanding and forecasting in 1973. Models of water quality have been developed which predict dissolved oxygen levels as a function of time and river location using number of inputs including flow rates. However, nowhere in the Statement can be found an indication if the change in the use of waterway and the latest understanding of environment were tested to see if indeed no meaningful alternative is feasible.

Discussion of alternatives is limited to the abandonment of navigation system or transfer of it to the State of Wisconsin or commercial interests, with the conclusion that transfer of control to the State can be considered a viable alternative. The transfer alone will have no impact on environment and should not be counted as a viable alternative. However, it can be assumed that after transfer, the State will review the rules of waterway operation with the aim of improving the unacceptable water quality deterioration during some summer months. With this in mind, the transfer would become a beneficial alternative.

The referenced statement was made within the context of competing water use interests and the existing laws, orders, rules and permits pertaining to regulation of the Lake Winnebago Pool. The subject of the possible need and value of flow releases for water quality purposes is covered extensively in Sections 2.56 - 2.58, 2.125, 4.218, 4.224, 4.228 - 4.232, and 6.83 - 6.91 of this statement. It is the position of the Chicago District that proposals for a significant change in operation of the Neenah-Menasha dams should reflect studies and recommendations developed pursuant to Section 208 of the Federal Water Pollution Control Act Amendments of 1972 by the Federal EPA, the Wisconsin DNR and the Fox Valley Water Quality Planning Agency; that streamflow for the purpose of water quality control not be a substitute for adequate treatment or other means of control of wastes at their source; and that the overall public interest be served to the greatest possible extent.

In addition to the various abandonment or transfer alternatives, the possible revision of existing control regulations for the Neenah and Menasha dams was discussed in the draft statement. Paragraph 6.18 of the final statement has been specifically revised to indicate that transfer of the Fox Project to the State of Wisconsin would provide the State with overall direct control of Lake Winnebago lake levels and downstream flow regulation of the Lower Fox River, but that the precise management actions tha the State might elect to take are unknown.

TOWN OF MENASHA

1000 Valley Road
Menasha, Wisconsin 54952
739-6120

February 3, 1976

U.S. Army, Chicago Engineer District
219 South Dearborn
Chicago, Illinois 60604

Draft Environmental Statement
relating to the operation and maintenance of the Fox River, Wisconsin Navigation Project.

Subject: Our comments on Revision of existing control regulations for the Neenah and Menasha Dams.

Dear Sirs:

For the past six months the Town of Menasha Planning Commission has made an in depth study of the artificial control of the level of Lake Winnebago. Our group has come to the conclusion that one point stands out which effects us is the buildup of the Winnebago pool during May and June near the maximum level of 21½" above the crest of the Menasha Dam for summer outflow.

According to House Documents, Vol. 17, Report on Reexamination of Fox River, 67th Congress - 2nd Session - 1921-1922, the Marshall order of 1886 set the level at 21½", which was modified in 1920 by Colonel Judson to read as follows:

1) The sluiceways in the Menasha Dam are placed by the Government to prevent damage by floods in Lake Winnebago. The Term 'flood' is to be considered to refer to all stages of water above an ordinary high-water stage. The ordinary high water stage will be taken as the mean highwater state or 21½ inches above the crest of the Menasha Dam.

We also have a private company. The Neenah and Menasha Water Power Company, organized April 5, 1883 according to State records. They organized for 'Leasing of Water for Power Purposes' only. They own the Neenah Dam and have exclusive rights to the surplus water from the Winnebago pool.

1. This surplus water is defined as from Lake level above crest of Menasha Dam down to dam level during navigation season to 18 inches below dam crest in the winter or close of navigation season.

2. According to State records in the articles of association of the Neenah and Menasha Water Power Company, Section 24, states the United States has superior authority to control waters of Lake Winnebago for navigation.

Our study revealed that no water power is used from the Neenah channel and only one company, Whiting Paper Company, on the Menasha channel uses water for power. Also, commercial navigation was ended in 1959 on the Fox River according to your report.

Under the terms of the various contracts and of the deed by which the United States acquired the navigation improvements, the water power owners everywhere on the Lower Fox River are entitled to use all surplus water not needed for navigation under the approved plan for regulation of Lake Winnebago.

In our research we found that the water level of the Menasha Dam is measured by the Oshkosh guage, which is located at the headquarters of the Department of Natural Resources, being that it is located in the center of the west side of the Lake, north and south winds do not effect it. Therefore, when the water level measured at Oshkosh is 18-19-20 or 21¼ inches above the crest of the Menasha Dam for the summer buildup, which occurs usually in the months of May and June with a strong south and southeast wind at these elevations the water will rise from eight to twelve inches on the north end of the Lake or the outfall of Lake Winnebago, and the guage at Oshkosh will not show this, due to the fact that it is in the center of the Lake. Under these conditions the water runs back into our drain ditches and road ditches and also on private property where flowage easements have never been paid, this affects the southeast area of the Town of Menasha.

2) When the water goes higher than the maximum of 21¼" over the crest of the Menasha Dam with all sluice gates open at Menasha and Neenah Dams, we have a buildup of water in Little Lake Butte des Morts because the outfall at the Appleton Dams is not as much as the water coming into Little Lake Butte des Morts. Under these conditions, we have a tremendous buildup of water backing up into drain ditches on some private property. We also have bank erosion, most of the shoreline of this Lake is in our Town. We did not find in our research of old records where any payments were made to property owners for flowage damage in the Little Lake Butte des Morts area when the Appleton Dams were built.

Therefore, this Study Group feels that a reading at the Oshkosh guage of 15 to 16 inches above the crest of the Menasha Dam for the summer storage of water for the Winnebago pool would relieve the conditions of Little Lake Butte des Morts, instead of the higher levels that have been maintained in the past. This would also give your Department more of a cushion to work with and you would have a better chance to hold the water within a maximum range of 21¼ inches above the crest of the Menasha Dam even with a south and southeast wind buildup.

3) According to part 2 of the Marshall Order which reads, "The manipulation of the sluices shall, as far as practicable, be such that, with minimum waste of water, high water shall not exceed 21¼ inches above the crest of Menasha Dam."

This manipulation of the sluices and water level above the crest of Menasha Dam also determines the flood plains and flood fringes, which in turn will determine the area where State and County Flood Plain Laws take effect also Flood Plain Insurance. On the broad front, this would include the entire Winnebago Pool and Little Lake Butte des Morts previously stated because it is all controlled by sluicing of the Neenah and Menasha Dams and the elevation of Lake Winnebago.

Your Project Engineer at Appleton has been most cooperative in answering our questions. If there are any statements in this report that you may question feel free to contact us.

Thank you.

[illegible]

The Oshkosh guage is one of the oldest and one of the most important on the Fox River. When the crest of Menasha Dam was reduced down 18 inches in 1882, and 18-inch flashboards substituted therefor, in compliance with a provision of the River and Harbor Act of 1882, readings of the Deuchman guage at the dam no longer showed the stage of the lake with as much accuracy as it had done previously. Accordingly, the Oshkosh guage was established to show the true stage of the lake, and this guage has since been used in connection with regulation of Lake Winnebago. It is graduated to correspond with the Deuchman guage, so that orders relative to the Deuchman guage also apply directly to the guage at Oshkosh. As it has been the basis of orders and extensive correspondence and has been involved in court decisions, all relative to the regulation of Lake Winnebago and payment of flowage damages by the United States, it is considered inadvisable to change the long established and accepted reference. As this guage, through years of reference, is thoroughly understood by all local water-power and riparian interests, any change in its elevation or form of graduation would probably meet with vigorous protest. Strong winds blowing on to the shore will produce high water due to wind setup and also wave runup (See Fig. 2.18). These may occasionall have damaging effects on shoreline property and structures. However, much of the present flooding adjacent to the lake is a result of encroachment within Federal flowage easements. The 1 February 1888 Act of Congress prohibits the paying of further damages resulting from Winnebago Pool overflow on private lands or other property.

Beyond the upper limit, the level of the lake depends upon the supply or inflow of water coming into the lake. The flooding on Little Lake Butte de Morts which occurs at these times of extreme high flows is beyond the operational control of the project and cannot be prevented. Flooding under such circumstances would be even greater under natural or "without project" conditions.

In accordance with the plan of regulation for flood control as described in paragraph 2.216 of this statement, the summer pool level on Lake Winnebago is maintained approximately 16 inches above the crest of the Menasha dam providing inflows are adequate to maintain this level. Whenever precipitation occurs, sluice gates are opened as required to limit the lake level to 21-1/4 inches above dam crest.

The term "flood" is to be considered to refer to all stages of water above an ordinary high-water stage. In the case of the regulation of Lake Winnebago this is taken to be 21-1/4 inches above the crest of the Menasha Dam. In accordance with the River and Harbor Act of 2 August 1882, and as far as the capacity of the Fox River below Menasha and the security and capacity of the structures will allow, the Menasha and Neenah Dams are operated to prevent Lake Winnebago from rising higher than 21-1/4 inches above the crest of the Menasha Dam. The City of Menasha presently has a State approved flood plain ordinance based on this long established method of operation of the Winnebago Pool and historical flood profiles of the Fox River.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
4601 Hammersley Road, Madison, Wisconsin 53711

February 4, 1976

Colonel James M. Miller
Department of the Army
Corps of Engineers-Chicago District
219 South Dearborn Street
Chicago, Illinois 60604

Dear Colonel Miller:

The draft environmental statement for the operation and maintenance of the Fox River, Wisconsin navigation project was referred to the Soil Conservation Service, Madison, Wisconsin on January 5, 1976. Our review comments are as follows:

1. Provisions should be made to vegetate spoil to prevent wind and water erosion.

   It has been our experience that dredged material deposits have not been subject to significant wind erosion since they have begun revegetating immediately after disposal operations have ceased. Topography and diking will preclude water erosion of deposited materials at the selected sites. Dikes will be protected against erosion by seeding or the use of stone riprap.

2. Disposal of dredged material on agricultural lands should be limited to amounts that can be readily incorporated into the plow layer.

   Concur. Dredged material will be deposited in layer amounts that can readily be incorporated into the plow layer.

3. The proposed works will not affect any existing Soil Conservation Service projects.

We appreciate the opportunity to review and comment on the proposed project.

Sincerely,

J. C. Hytry
State Conservationist

cc: R. Davis, SCS, Washington, D.C.
Council on Evt. Quality, Washington, D.C. - 5 copies
Office of the Coord. of Evt. Quality Activities, Washington, D.C.
G. Framberger, SCS, Oshkosh, Wisconsin

United States Department of the Interior

OFFICE OF THE SECRETARY
NORTH CENTRAL REGION
230 S. DEARBORN STREET, 32nd FLOOR
CHICAGO, ILLINOIS 60604

ER 75/1207 February 5, 1976

Colonel James M. Miller
District Engineer
U. S. Army Engineer District
Chicago
219 South Dearborn Street
Chicago, Illinois 60604

Dear Colonel Miller:

The Department of the Interior has reviewed the Draft Environmental Statement relating to the Operation and Maintenance of the Fox River, Wisconsin Navigation Project, Wisconsin, as requested in your transmittal letter of December 15, 1975, to our Assistant Secretary, Program Development and Budget. Our comments which are of both a general and specific nature relate to areas of our jurisdiction and expertise.

General

The statement is more or less restricted to a discussion of recreational boating and fishing. Other uses of the shore and wetlands for activities such as nature walks, birding, photography, picnicking, and hunting should be discussed and the impacts of the project and alternatives described.

Also, we find no comment concerning impacts of the project on shallow and unconfined aquifers; these should be considered in the preparation of the final statement. Although control of surface-water levels is mentioned for many parts of the project, the effects of such actions on groundwater levels in the affected areas should be evaluated.

Specific

2. ENVIRONMENTAL SETTING

NATURAL ENVIRONMENTAL ELEMENTS

Page 2-3: Within the Fox River study area there are 17 parks located adjacent to the affected water bodies, which have been assisted by monies from the Land and Water Conservation Fund (LWCF). These projects are identified and located as follows:

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

Since boating and fishing are the recreational activities most directly affected by the Federal project, these were the activities given the most attention in the draft statement. Appropriate portions of Sections 2, 4 and 6 of the final statement have however been revised to incorporate additional discussion on each of the referenced recreational activities.

Precipitation is the primary factor affecting groundwater levels and movements in the project area. Project area streams and lakes are areas of discharge to which groundwater contributes most of the flow 90 percent of the time. Project flow regulation practices have only a very minor influence on groundwater levels and storage. The minor, short-term fluctuations which may occur as a result of controlled water level management are limited to the immediate zone surrounding the Lake Winnebago pool area. Groundwater relationships to project surface waters are discussed further in paragraphs 2.65 - 2.71 and 2.192 of this statement.

Outagamie County:
Wolf River
Wolf River Park (55-00238) near New London

Fox River
Sunset Park (55-00339), Kimberly
Little Chute Doyle Park Development (55-00516, active), Village of Little Chute
Kaukauna Bayorgeon Park Development (55-00702), City of Kaukauna

Marquette County: (Located outside the Fox River Study Area but are included for information purposes)
Lake Buffalo-Fox River
Montello Lock and Dam (55-00227), Montello
Montello City Park (55-00295), Montello

Green Lake County: (Located outside the Fox River Study Area but are included for information purposes)
Fox River
Princeton Dam (55-00007), Princeton
Riverside Park (55-00118), Berlin
Riverside Park Addition (55-00469), Berlin
Webster Street Park Acquisition (55-00927), Berlin

Winnebago County:
Wolf River
Winneconne Boat Landing Acquisition (55-00720), Village of Winneconne

Fox River
Oshkosh Riverside Park (55-00727), Oshkosh

Lake Winnebago
South Side Boat Launching Site (55-00016), Oshkosh
Neenah Fresh Air Camp Addition (55-00434), Neenah
Neenah Fresh Air Camp Acquisition (55-00880), Neenah
Menasha Jefferson Park Development (55-00476), Menasha
Oshkosh Menominee Park (55-00493 active)
Winnebago Osh-O-Nee Boat Launching Acquisition (55-00959 active) Winnebago County, North of Oshkosh

Fond Du Lac County:
Lake Winnebago
Small Boat Docking Facility, Lakeside Park (55-00032), Fond Du Lac
Launching Facility, Lakeside Park (55-00033), Fond Du Lac
Columbia (55-00196), Fond Du Lac County, near Calumet Harbor

Calumet County:
Lake Winnebago
High Cliff State Park (55-00008, 00057, 00248, 00487, 00725)

Brown County:
Fox River
Ashwaubenon Fox River Community Park (55-00489), Ashwaubenon
Ashwaubenon Park Development (55-00691 active)

The impact of the project and alternatives on the above projects cannot be assessed within the allotted review time. However, our Bureau of Outdoor Recreation is willing to assist you in assessing these impacts. The Wisconsin Department of Natural Resources (Mr. John A. Beale, Administrator; Fish, Game, and Recreation; Department of Natural Resources; Box 450; Madison, Wisconsin 53701) and local sponsors also should be contacted regarding these LWCF parks.

Each of the subject LWCF parks has been developed on the basis of long established project conditions. These conditions are not known to have had a significant adverse impact on these or any other park investments in the project area. Since no change in project features or the general operation of the project is proposed, the requested site specific assessments are considered to be unwarranted and beyond the scope of this document. The only LWCF park which will be significantly impacted by the specific proposed action is Columbia Park in Fond du Lac County near Calumet Harbor on Lake Winnebago. Dredged material disposal is proposed at this park site (See Figure 1.15 and paragraph 4.86). The Fond du Lac County Parks and Development Committee, the Fond du Lac County Planning Department, and the Wisconsin Department of Natural Resources have reviewed and approved the plans for maintenance dredging and disposal at this location.

Page 2-5, paragraph 2.04: In view of the severe magnitude of spring floods that result from the combination of heavy rainfalls and rapid snow melt, effects of flooding on industrial and residential development on the river banks should be assessed.

Concur. Paragraphs 2.92 - 2.119, 4.169 - 4.172 and 4.221 - 4.223 of the final statement have been revised to include this information.

Page 2-25, figure 2.6: Although the distribution of sludge beds in the Lower Fox River from paper mill effluents is indicated, an appropriate statement should be included (p. 2-23, par. 2.35) regarding the relation of sludge beds to proposed dredging sites. It would be useful to show dredging sites on figure 2.6.

The sections of the waterway that most frequently require maintenance dredging are the approaches to the locks and two restricted river sections at Sunset Point and Grignon Rapids. Figure 2.7 of the final statement has been revised to locate major sludge beds in relation to these sites. Specific sediment sample results for areas to be dredged are contained in Appendix B.

Historical Places, Archeological Sites and Natural Landmarks

Page 2-70, paragraph 2.114: The statement recognizes that the Fox River area is rich in archeological sites and that undiscovered sites probably exist. The State Historic Preservation Officer has recommended that a reconnaissance survey be conducted of project lands and disposal sites and the Corps of Engineers has agreed to "closely coordinate these surveys with the State Historic Preservation Officer."

A further statement is needed that in the event that historic or archeological properties listed in or eligible for listing in the National Register of Historic Places would be affected by the proposed action, the procedures for the protection of historic and cultural properties (36 CFR Part 800) established by the Advisory Council on Historic Preservation will be complied with.

A recently completed archeological assessment survey has shown that there are no sites in, or eligible for, the National Register of Historic Places which will be affected by the proposed action. Paragraph 4.109 of the text has been revised to include the statement that the Chicago District will comply with established Advisory Council procedures in the selection of future additional disposal sites.

Recreational Features

Page 2-74 to page 2-95: Discussion of the recreational features of the project area should include an appropriate statement regarding sanitary waste disposal facilities, especially for those areas used for boating (p. 2-74 to 2-88), and for camping and picnicking (p. 2-90).

Sanitary waste disposal facilities at land based recreational sites in the project area are described as adequate according to the current Outdoor Recreation Plan for the State of Wisconsin. The Wisconsin Department of Natural Resources has indicated that the marine sanitary facilities at Green Bay, Appleton, Oshkosh and Fond du Lac are adequate to service recreational boats with holding tanks utilizing project waters.

4. PROBABLE IMPACTS OF THE PROPOSED ACTION ON THE ENVIRONMENT

NAVIGATION SYSTEM IMPACTS

Dredged Material Disposal

Page 4-5, paragraph 4.14: The impacts of depositing spoil on parkland should be carefully discussed and documented. This should include documentation of approval of spoil deposition by the park administrator, description of existing land and use (i.e., do "low spots" provide wildlife habitat and are they used and/or needed for nature walks, birding, wildlife and photography), and whether disposal fits into the master plan of the park.

Of the parks named in Table 1.3, page 1-10 as possible disposal sites, none are funded with LWCF monies. One site at the Calumet Harbor is listed as east of Columbia Park. This park has been assisted with LWCF monies. Any impact on this park due to an adjacent disposal site should be discussed.

DAM OPERATION IMPACTS

Neenah-Menasha Dam Operation Impacts

Page 4-8, paragraph 4.33: The impact of high water levels on recreational facilities should be indicated. Does this cause inundation of any park areas or developments?

Page 4-9, paragraph 4.37: It should be noted that some of the public recreation areas or facilities were funded with LWCF monies. A reduction in lake levels could negate the Federal recreation investment.

6. ALTERNATIVES

ALTERNATIVES WITHIN THE PRESENT PROJECT

Enhancing Project Recreational and Conservation Features

Page 6-8, paragraph 25: Project modification in this direction appears favorable with regard to general recreation and is in accord with stated objectives and recommendations of the Wisconsin Statewide Comprehensive Outdoor Recreation Plan. We agree, however, that further study would be necessary.

Sincerely,

for Madonna F. McGrath
Acting Special Assistant
to the Secretary

The only park to be impacted by project dredged material disposal is the county park site at Calumet Harbor. The disposal site at this location was selected by the Fond du Lac County Planning Commission and approved by the Fond du Lac County Board of Supervisors at the recommendation of the County Parks and Development Committee (8 April 1975 resolution No. 15-75). This committee has the responsibility of administering the County Parks. The proposed disposal plan has been found by Federal, State, and local officials to be consistent with park plans and current usage.

Table 1.5 of this statement has been corrected to show that dredged material disposal is proposed at Columbia Park. The impact on this park is discussed in paragraph 4.86 of the text and is elaborated upon above in responses to previous comments.

The project waterway system has been in existence for many years. Alterations from the original channel and particularly from original water levels have created a new set of conditions along the project that have assumed the appearance of permanency. Over the years, public and private recreational sites and facilities involving a considerable investment have developed along the project on the basis of long established project conditions. The Chicago District recommendation that these dams be operated in substantially the same manner as at present will therefore insure that the local recreational economy and the recreational investment that has been made over a long period of years is protected and not subjected to adverse effects of damaging high water levels.

Text has been revised as requested (See paragraph 4.184).

Comment noted.

THE INSTITUTE OF PAPER CHEMISTRY
Appleton, Wisconsin 54911
Phone 414 734-9251

February 5, 1976

James M. Miller
Colonel, Corps of Engineers
District Engineer
Department of the Army
Chicago District
219 South Dearborn Street
Chicago, Illinois 60604

Dear Colonel Miller:

The following paragraphs convey my opinions on the document, "Draft Environmental Statement Relating to the Operation and Maintenance of the Fox River, Wisconsin Navigation Project" as prepared by the United States Army Engineer District, Chicago, Illinois. The comments expressed herein are essentially my personal views although these opinions were formulated largely through my experience as a member of the Aquatic Biology Group of The Institute of Paper Chemistry.

I would like to thank the U. S. Army Engineering District for requesting my comments on this statement.

Because my experience on the Fox-Wolf-Winnebago System is mainly related to aquatic ecology and water quality, I shall confine my remarks to those two features of the Draft Environmental Impact Statement.

In general, I found this document to be technically correct regarding the historical aspects of both aquatic ecology and water quality of the Fox-Wolf-Winnebago System. I offer the following comments on certain specific issues referenced in this report:

Section 1.20

In this section, mention is made that dredge materials found to be polluted will be deposited in completely confined lake or river areas or on shore. I would suggest that the nature of "polluted" sediments be defined (e.g. in terms of sanitary, heavy metals, and chlorinated hydrocarbon aspects).

Paragraph 1.26 of the final has been revised to clarify that the polluted sediment classification used in this report is based on established USEPA sediment quality guidelines (See Appendix B, Tables B.9 and B.10).

Comment	Response
Section 2.34 This discussion of heavy metal pollution would be complemented by the inclusion of data regarding the heavy metal content of certain organisms which are known to accumulate heavy metals. Also worthy of consideration in this general area would be such toxic substances as polychlorinated biphenyls (PCBs).	This subject was discussed in the draft statement in as great detail as possible based on available data.
Section 2.141 I am concerned that the boat-use activities discussion did not document the very obvious and rather recent fishery in Little Lake Butte Des Morts. I believe that since 1970, the boat-use activities on Little Lake Butte Des Morts have gone from almost exclusively cruising to a combination of fishing and cruising in response to an emerging panfish fishery.	The recent fishery improvements in Little Lake Butte des Morts and at certain other locations along the Lower Fox River are described in Sections 2.153 and 2.275 - 2.277 of this report.
Section 2.199 While dissolved oxygen problems do exist within the Lower Fox River and such conditions limit certain aquatic forms, the entire Lower Fox River is not affected by this phenomenon. I believe the concluding statement in this section should be tempered along those lines.	Paragraph 2.260 of this statement has been modified accordingly.
Section 2.`03 Attached to this letter please find a species list of phytoplanktors collected from the Lower Fox River during the summer of 1973 under an Institute Project.	The treatment of this subject in the final statement has been revised accordingly.
Section 2.209 Attached to this letter please find some pertinent data relating to the zooplankton populations of the Lower Fox River. Please note this data is largely historical in nature as it spans the period 1955-1964.	Paragraph 2.269 of this final statement has been revised to reflect this additional information.
Sections 2.210 and 2.211 A third enclosure accompanying this letter contains a "species" list of macroinvertebrate forms found in the Lower Fox River during the summer of 1975. Please note that these data represent animals found on artificial substrate sampling devices. Studies performed by the Institute have documented the existence of sensitive or intolerant macroinvertebrate forms in virtually all areas of the Lower Fox River under high and moderate flow conditions. Low flow and high temperature periods reduce and in some cases eliminate these "intolerant" forms from certain sections of the Lower Fox River as evidenced by annual studies from 1971 to 1975.	Paragraphs 2.270 - 2.271 and Table 2.37 of the final have been revised so as to incorporate this new information and data.

Section 2.214

I am somewhat surprised to note in Table 2.51 that such fish species as: yellow perch, walleye, sauger, bluegill, white bass, and others are not considered present in the Lower Fox River. While I have no solid data at hand to offer in this regard, I have personally seen catches of fish from the Lower Fox River which included those mentioned and others.

Paragraphs 2.276 - 2.277 and Table 2.39 of the final have been revised to reflect the best available fishery data for the Lower Fox River.

Section 4.03

Within this section the statement is made that the Lower Fox River is too polluted to support any spawning populations of fish. I believe this statement to be false and cite as prime examples of probable spawning fish populations, the yellow perch of Little Lake Butte Morts and the Lower Fox River at least as far downstream as the College Avenue Bridge in Appleton and carp throughout the entire length of the Lower Fox River. How much potential spawning habitat for these and other fishes in the Lower Fox River would be affected by dredging and snagging is beyond the scope of my experience.

The subject statement in paragraph 4.49 of the final has been modified from "too polluted to support any spawning populations of fish" to "too polluted to support spawning population of most fish species."

In conclusion, I would like to restate my earlier opinion that in general I find this document to be a reasonably accurate assessment of environmental conditions relative to the *Fox River Navigation Project*. *I would, however,* emphasize that much of the biological and water quality data are of an early 1970 vintage and that projections made on that data may not accurately reflect present environmental conditions in the Fox-Wolf-Winnebago System.

The final statement has been extensively revised in order to include the best biological and water quality data currently available. Assessments based on data which may not accurately reflect present environmental conditions have been appropriately qualified.

Sincerely yours,

David L. Rades
Research Associate
Division of Industrial and
Environmental Systems

Listing of Attachments (Data on File in Chicago District Office):

I. Phytoplankton Species Collected in a Series of Summer Water Samples from the Lower Fox River, Wisconsin - 1973

II. Zooplankton Analyses - Fox River, April 11-14, 1955

III. Plankton Analysis - Routine Samples - Lower Fox River - 1957

IV. Zooplankton Analyses - Routine Samples - Lower Fox River - 1959

V. Zooplankton Analyses - Routine Samples - Lower Fox River - 1961

VI. Zooplankton Analyses - Routine Samples - Lower Fox River - 1964

VII. Macroinvertebrate Species Found on Artificial Substrate Samplers in the Lower Fox River During 1975

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
COMMANDER (mep)
Ninth Coast Guard District
1240 East 9th St.
Cleveland, Ohio 44199
Phone: 293-3919

5922
6 February 1976

Department of the Army
Chicago District, Corps of Engineers
219 South Dearborn Street
Chicago, Illinois 60604

Re: Draft Environmental Statement:
Operation and Maintenance;
Fox River, Wisconsin Navigation Project;
December 1975

Dear Sir:

The Draft Environmental Statement, referenced above, has been reviewed by this office and we offer no comments at this time.

Sincerely,

W. C. OCHMAN
Captain, U. S. Coast Guard
Chief, Marine Safety Division
By direction of the Commander,
Ninth Coast Guard District

Feb 6 - 1975

To - Department of the Army
Chicago District, Corps of Engineers
219 South Dearborn Street
Chicago, Ill. 60604

Dear Mr Miller:

In regard to the Draft Environmental Statement I was amazed to see all the records of your Environmental Statements and all the work that was connected to it.

My statement is that Brothertown harbor could be improved by driving piling along the north side of the harbor to keep the ground from washing in.

One more thing I am bitterly against on having open season for fishing in spawning time up the rivers during April and May

Sincerely Yours
Harold Schmitz
Chairman
Town of Brothertown

(P.S. Address)
Harold Schmitz
R3 Chilton
Wis, 53014

The shoreline of Brothertown Harbor may be described as in generally fair to good condition, but certain areas may soon require some maintenance due to erosion, settling, or other deterioration.

All fish and game regulations in the State of Wisconsin are established and administered by the Wisconsin Department of Natural Resources.

Advisory Council
On Historic Preservation
1522 K Street N.W.
Washington, D.C. 20005

February 13, 1976

Col. James M. Miller
District Engineer, Chicago District
U. S. Army Corps of Engineers
219 South Dearborn Street
Chicago, Illinois 60604

Dear Col. Miller:

This is in response to your request of December 15, 1975, for comments on the draft environmental impact statement for the Operation and Maintenance of the Fox River, Wisconsin Navigation Project. Pursuant to our responsibilities under Section 102 (2) (c) of the National Environmental Policy Act of 1969, we have determined that, to date, your draft environmental impact statement appears to be procedurally adequate. We note that you intend to comply with the request of the Wisconsin State Historic Preservation Officer to provide for an archeological survey of Federal lands and new dredged material disposal sites in the Project area.

We request that the final environmental statement show compliance with our procedures (36 C.F.R. Part 800). The evidence will take the form, as appropriate, of documentation of no adverse effect, a copy of our concurrence in your determination of no adverse effect, or an executed memorandum of agreement. The final environmental statement should also include a copy of the comments of the Wisconsin State Historic Preservation Officer.

Should you have any questions or desire additional information. please contact Charles Spilker of the Advisory Council staff at (202) 254-3380.

Sincerely yours,

John D. McDermott
Director, Office of Review and Compliance

The Council is an independent unit of the Executive Branch of the Federal Government charged by the Act of October 15, 1966 to advise the President and Congress in the field of Historic Preservation.

Letter documentation of no adverse effect from the Wisconsin State Historic Preservation Officer is shown in Figure 2.14 of this report. Also see paragraphs 2.191 and 4.106 - 4.109.

City of Menasha

OFFICE OF THE MAYOR

P O BOX 359 / 175 MAIN ST MENASHA WI 54952

February 20, 1976

U. S. Army, Chicago Engineer District
219 South Dearborn
Chicago, Ill. 60604

Dear Sirs:

Subject: Draft Environmental Statement relating to the operation and maintenance of the Fox River, Wisconsin Navigation Project

Our City has not made an extensive study of this subject. My review of the Draft Statement was very educational as it covers many aspects of the Project.

The only comment I could make would be to regulate the level of Lake Winnebago so that at no time would the level exceed the 21½ inches in any part of the Lake.

Thank you for the opportunity of making this response.

Sincerely

Victor V. Wiecki

Victor V. Wiecki
Mayor

VVW:je

The large excess of inflow over outflow at times makes it physically impossible to regulate the level of Lake Winnebago below the prescribed flood limit and still avoid excessive waste of water to which water-power interests have established legal rights.

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
230 SOUTH DEARBORN ST
CHICAGO, ILLINOIS 60604

RE: 75-114-126
D-COE-F32034-WI

M... 1976

Colonel James M. Miller
District Engineer
U. S. Engineer District, Chicago
219 S. Dearborn Street
Chicago, Illinois 60604

Dear Colonel Miller:

In response to your letter of December 20, 1975, we have reviewed the Draft Environmental Impact Statement (EIS) for the Operation and Maintenance of the Fox River Navigation Project. Our principal concerns relate to water quality, specifically with regard to the disposal of dredge spoil and operational measures affecting flows, pool levels, and wetlands. We offer the following comments for your use in preparing the Final EIS.

As implied by the variances and additions to the Wisconsin Water Quality Standards for the Fox River, meeting the dictates of the Federal Water Pollution Control Act Amendments of 1972 in the Fox River system will be extremely difficult and expensive. The operation and maintenance of the Fox River navigation project has a substantial effect on the hydrology of the Fox River system, hence the water quality. Therefore, more information and studies should be incorporated in the EIS so that alternatives to operation and maintenance of the project consider the related effects on water quality. The existing operational scheme relating to flows regulated by the project is in need of a thorough evaluation. Flow augmentation for water quality purposes is not a suitable substitute for adequate treatment or other methods of controlling waste at the source. We recognize, however, the potential beneficial effects upon water quality and support your efforts to consider water quality impacts in evaluating various operational schemes. Beneficial impacts on water quality may also be available by utilizing the potential of adjacent wetlands to assimilate nutrients. Proposals for changes in flows and pool levels should reflect studies and recommendations made by the Wisconsin Department of Natural Resources (DNR). Please keep us advised of the various operational schemes as additional information is made available from the Wisconsin DNR.

With regard to the Operation & Maintenance activities, the disposal of dredge spoil presents the most significant threat to water quality. The formulation of a suitable dredge spoil disposal plan should minimize adverse impacts. We look forward to participating with you and other concerned agencies in developing this plan. The Final EIS should recognize the agencies participating in this plan and indicate that the plan is subject to the approval of these agencies. Also, more information should be provided on the dike construction for containing dredge spoil. It appears from Table 1. 3 that most of the sites will be diked only on the river side or not

The procedures for project streamflow regulation can be changed if required to improve Fox River water quality within the limits of regulation authorized by the Congress. Additional information and data relating to project flow regulation procedures and water quality on the Lower Fox River is included in Sections 2.56 - 2.58, 2.125, 4.218, 4.224, 2.228 - 4.232 and 6.83 - 6.91 of the final statement. We agree that the existing operational scheme relating to flows regulated by the project is in need of further evaluation, but that any specific proposals for chang[e] in flows and pool levels should reflect studies and recommendations made by the Wisconsin Department of Natural Resources and other appropriate public agencies. We recognize the contribution of wetlands in tying up nutrients which would otherwi[se] contribute to the eutrophication of lakes and streams. However, it must be noted that the pool regulation procedures most favorable to wetland conservation and management (reduced water levels and pool fluctuations) tend to conflict with lake regulation management for stream sanitation purposes.

Table 1.5, Figures 1.4 - 1.16 and 4.2 - 4.3, and paragraphs 1.26 - 1.29 and 4.65 - 4.116 have been revised to include this information.

diked at all. More information should be provided on how the polluted spoil will be contained and how any discharges from the disposal sites will avoid degrading water quality. Detailed maps or photographs should be provided in the EIS to illustrate each dredge spoil disposal site and more information should be provided with regards to impacts on wetlands.

Since some of the spoil will be given to local landowners to fill "low" areas, we believe adverse effects could be avoided if adequate controls are required regarding this disposal practice. In making the disposal material available to benefit local landowners, preference should be given to landowners who utilize good land management practices. The disposal of this material should not be permitted in wetland areas. Paragraph 4.90 discusses the application of dredged material on agricultural lands. The comparison of the possible effects of heavy metals concentrations in sewage sludge and in dredged material is of doubtful validity. Uptake of heavy metals is dependent upon a number of variables such as pH, presence of organic carbon, and the nature of the crop itself. Prudence would dictate sampling and testing of vegetation grown in contaminated spoil.

The limits of various parameters used by EPA to determine the pollutional status of sediments should be referred to as guidelines and not criteria.

In the section on alternatives, the discussion of dredging (6.17 and 6.18) should be expanded to indicate differences in estimated quantities of dredge spoil generated through maintenance of navigation channels at various depths. In determining the optimum channel depth, consideration should be given to the amounts of dredge spoil and the environmental implications associated with disposal.

Annual operation and maintenance cost is given in paragraph 4.26 as $361,000, however, paragraph 8.09 quotes a figure of about $1 million. In either case, we agree that the expenditure of public funds in support of private recreational navigation interests warrants close economic scrutiny. Such action is particularly imperative in view of the fact there has been no commercial navigatioin through the system for over 15 years.

Tables 2-22 and 2-50 should be updated to reflect existing or more recent conditions. In accordance with the Water Quality Management Plan (40 CFR, 130131) for the Fox-Wolf River Basin dated August, 1975, Table 2.4 should include additional point-source dischargers such as the Hillshire Farm Company and Currwood Inc. in New London, and the Winneconne Water Department and Zimmerman's Milk Plant in Winneconne. Also, it should be indicated that the City of Oshkosh has replaced its primary plant with secondary facilities.

Disposal will not be undertaken in any wetland or marshy portions of farm property. In making the disposal material available, preference will be given to landowners who utilize good land management practices. While it is true that there are a number of variables affecting heavy metal uptake in agricultural crops, the comparison of the possible effects of dredged materials on agricultural lands used in the draft is still considered to be valid in view of the very small fractions of toxic materials present in dredgings proposed for disposal in this manner. This may be further illustrated by the following comparison.

Toxic Metal Concentration Comparison

	1/ MSDGC Prairie Plan	Fox Project Plan
Mercury	3.89 ppm	.05 ppm
Lead	110 ppm	.65 - 8.82 ppm
Zinc	320 ppm	13.7 -50.1 ppm

1/ Metropolitan Sanitary District of Greater Chicago

The final statement has been modified accordingly.

Section 6 of the final statement has been modified accordingly (See paragraphs 6.20 - 6.29).

The $1 million figure quoted in paragraph 8.09 of the draft statement represented the total cost to operate and maintain the entire Fox Project during calendar year 1974. The $361,000 cited in paragraph 4.26 of the draft referred only to the estimated portion of the total cost required to operate and maintain the Federal lock system.

In our view, the data presented in Tables 2.22 and 2.50 of the draft statement are representative of current land use and biological conditions in the project area. Table 2.4 of the draft has been deleted from the final. The secondary sewage treatment at the City of Oshkosh is noted in paragraph 2.31 of the final.

In paragraph 2.41, the last sentence incorrectly equates the piezometric surface with the surface of the water table. A piezometric surface is an imagenary surface representing the height to which water will rise in a well that taps an artesian aquifer. In this case, there is a deep artesian aquifer as well as a water table. It is the configuration of the latter, along with the geologic structure, that will determine the ground surface water interrelationships within the project area.

Concur. The sentence has been deleted.

A Section 208 (PL 92-500) plan is being prepared for the Fox River by the Fox Valley Water Quality Planning Agency. Although the plan will be completed in approximately two years, coordination with this agency should be initiated as soon as practicable. The EIS should mention the Level B Study for the Fox River, and the relationship of the Level B Study to future O&M activities should be addressed. At the completion of the Level B Study and the 208 Plan, consideration should be given to preparing an updated EIS.

The relationship of future operation and maintenance activities to the referenced resource management studies is discussed in paragraph 3.16 and the general response portion of Section 9 of the final. We agree that the outcome of these and other planning investigation programs may have an effect on the current management policies of the project. We anticipate that continuing contact between our agency and others as we interface with 208 water quality planning and other basin related studies will result in the development of the optimum management plan for the river system. At the completion of these studies, the Chicago District will be in a better position to reevaluate the Fox Project within the context of overall regional needs and the public interest. Prior to the implementation of any specific proposal which would substantially modify the Federal project and its operation, the Chicago District would prepare an updated EIS.

We have classified our comments as Category LO-2. Specifically, this means we have no major objections to the project; however, we believe additional information is needed in the EIS to fully evaluate alternatives and associated environmental impacts. This classification and the date of our comments will appear in the Federal Register. We appreciate the opportunity to review this Draft EIS. Please send us two copies of the Final EIS when it is filed with the Council on Environmental Quality.

Sincerely yours,

Gary A. Williams

Gary A. Williams
Chief,
Environmental Review Section

EAST CENTRAL WISCONSIN
Regional Planning Commission

1919 AMERICAN COURT • NEENAH, WISCONSIN 54956 • PHONE (414) 739-6156

March 12, 1976

James M. Miller, District Engineer
Chicago District, Corps of Engineers
219 South Dearborn Street
Chicago, ILL 60604

Dear Col. Miller: EC Review No. EIS 75-248

RE: Clearinghouse Review Comments - Draft Environmental Statement Relating to the Operation and Maintenance of the Fox River, Wisconsin Navigation Project

The East Central Wisconsin Regional Planning Commission has reviewed the "Draft Environmental Statement Relating to the Operation and Maintenance of the Fox River, Wisconsin Navigation Project" in response to your request of 12/15/75. The comments are made relative to the environmental considerations contained in the Draft Statement in accordance with the National Environmental Policy Act of 1969.

The enclosed statement strictly relates to the contents, analysis and format of the Draft Statement document and does not reflect East Central's formal position on alternative follow-up courses of action. However, East Central reserves the right to submit a Commission position on alternative actions affecting the Corps future management of the Fox-Wolf project area at the appropriate time and place.

East Central wishes to congratulate the Corps of Engineers on the quality of the Draft Statement as it is one of the most complete compendiums of environmental information for the Fox-Wolf project area. East Central's comments are intended to help improve portions of the document and clarify certain issues critical to the Fox Valley area. We wish to thank the Corps for the opportunity to comment on the Statement.

Sincerely,

Roy C. Willey, Jr.

Roy C. Willey, Jr.
Executive Director

RCW/HPK/bl
cc: Ross Plaines, Corps of Engineers, Appleton
Anthony Earl, Secretary, DNR, Madison
Stanley DeBoer, District Director, Green Bay DNR
Walter Naab, Area Director, Oshkosh DNR

East Central Wisconsin Regional Planning Commission

Review Comments on the "Operation and Maintenance of the Fox River Wisconsin Navigation Project - Draft Environmental Statement"

This report contains comments, concerns and suggestions on the technical content and adequacy of the Draft Environmental Statement of the Corps of Engineers Operation and Maintenance of the Fox River, Wisconsin Navigation Project. The analysis and comments following relate generally to each of the nine primary sections of the statement followed by specific references to various sub-elements within the primary sections.

Section 1 - The Fox River, Wisconsin Federal Navigation Project

This initial section explains the Corps basic authority and management operations relating to the Fox River Project. Although the general authority, consisting of various legislative and federal regulative references, is listed in this section, the basic purpose or purposes of the federal project are not stated in a concise and comprehensive nature. Many of the purposes and varied management responsibilities of the Corps project are listed in other sections of the statement. An introductory explanation listing the authority and management responsibilities of the Corps, in such areas as navigation, flood control, water power regulation, riparian land owner interests and fish and wildlife interests would increase the readers' comprehension of the Corps management impacts in these areas. It would also be worthwhile to list the various permit programs which affect land and water use within the project area. This initial information is vital when viewed in support of the identification and analysis of the environmental and socio-economic impacts of the project contained in later sections of the statement.

All of the management operations relating to the Fox River Project were presented in Section I of the draft statement. Each of these varied management responsibilities were discussed in a manner sufficient to provide a basic and concise overall understanding of the existing Federal project and the proposed Federal action. Additional project descriptive information and data was included in other statement sections only to the extent considered necessary to adequately identify and develop the required information in accordance with environmental statement guidelines established by the Council on Environmental Quality. Detailed information and data pertaining to project regulations, features, and operational procedures were appropriately placed in report appendices. The permit program responsibilities of the Chicago District are not within the scope of this statement. The decision whether to issue a permit for any given activity is based on a separate evaluation of the probable impact of the proposed activity on the public interest.

Section 2 - Environmental Setting

This section inventories and describes the environmental and socio-economic features of the project area. The section is comprehensive, quite conclusive and lists a good inventory of the project area's natural features. An approach which could be used, however, throughout this section, which would assist in analyzing the future impacts of Corps management operations on environmental and socio-economic factors, would be the establishment of environmental and socio-economic trends. Although establishing trends which clearly identify future impacts is difficult, primarily because of lacking long-term data, this process could identify impacts not easily recognizable and also more clearly explain identified impacts.

Appropriate information and data relating to socio-economic trends in such areas as project operating costs, boating demand, water quality, wetlands, municipal, and hydropower water uses are included in the final statement.

Another area of concern within this section is the "Human Element" portion. A sub-element under this category should describe the municipal and industrial water use primarily associated with the Lower Fox River. This information should concern itself with the municipal and industrial waste discharge activities as well as the water power and water supply needs of utility and industrial users. A good inventory of the physical facilities and principal water

Concur. Paragraphs 2.118 - 2,125 of the final statement have been revised to include information on water use in the project area.

users of the Lower Fox River is included in "Text and References, The Watershed's Resources, The Wisconsin Fox River Valley Watershed", Environmental Studies Project, University of Wisconsin - Green Bay, 1975. This preceding information would be most valuable in analyzing the impacts of the Corps water power management activities in respect to the Lake Winnebago and Fox River water level and flow responsibilities.

A final general area of comment concerns additional information within the "Hydrologic Element". Although flooding is briefly described, additional information, such as flooding and flood damages on the Fox and Wolf Rivers and flooding associated with Lake Winnebago level controls, would be helpful. The operation of the Menasha dam is not the only flood related activity performed by the Corps. Flood prevention equipment and aid in other areas is also part of the Corps flood relief efforts.

The subject section has been revised to include additional flooding and flood damage information on the Fox and Wolf Rivers and Lake Winnebago (See paragraphs 2.192 - 2.219). General flood relief efforts, equipment and aid are not directly related to project operation and maintenance, and are not considered a part of this statement.

Following is a specific listing of minor comments related to portions of the "Environmental Setting" section:

Page 2-19, Paragraph 2.30 - There is an ongoing water quality investigation taking place on the Lower Fox River and Lake Winnebago, i.e., 208 water quality planning via the Fox Valley Water Quality Planning Agency. There will also be a comprehensive Fox-Wolf River Basin planning program dealing with major problems and future management of the basin via a "209 or Level B Basin Plan" scheduled to begin in 1976. These planning efforts should also be discussed in Section 3 "Relationship to Land-Use Plans and Policies".

The referenced ongoing water quality investigations are discussed in paragraph 3.16 and the General Response portion of Section 9 of the final statement.

Page 2-74, Recreational Features - Existing recreational facilities and uses of Corps lands should be listed and discussed.

Physical and operational constraints associated with authorized project lands and features have prevented the development of recreational facilities on Federal properties. Public recreational use of the project lands is limited to occasional lock tours and visits by school classes, scouts, and other groups.

Page 2-78, Paragraph 2.123 - This paragraph estimates boat usage on the Winnebago Pool and Wolf River. The 300 boats per weekend day versus 450 boats per weekday usage on the Wolf River should be rechecked. These fitures may be reversed as higher boat usage seems to be evident and logical on weekends. This comment also applies to page 2-82, paragraph 2.131.

The entire recreational boating analysis of the draft statement has been revised. The system boating usage information and data presented herein is based on a recent Chicago District survey of Lake Winnebago and Lake Michigan waters (See paragraphs 2.134 - 2.139). As might be expected, this study found that weekend use exceeded weekday use in the Lake Winnebago area. While a direct comparison of the results of this study with the findings of the Wolf River area water patrolmen as reported in the draft cannot be made, it is probably safe to assume that the weekday-to-weekend day use ratio is higher for the Wolf River area than other portions of the system.

Page 2-92, Table 2.38 - Portions of the recreational facilities inventory are incorrect, i.e., there are not 11 state parks in Brown County. This table should be rechecked.

The recreation facilities inventory information in this table has been rechecked. The corrected table appears on page 2-62 of the final statement.

Page 2-96, Paragraph 2.166 - Four principal interests for management of Lake Winnebago are indicated. The fourth interest, fish and wildlife, is not discussed in this paragraph.

The subject fish and wildlife interest was discussed in paragraph 2.167 of the draft statement.

Page 2-98, Hydrologic elements - Additional historical information on Lake Winnebago levels and factors affecting these levels would be helpful in determining the impacts of lake level management. Problems of level management could be expanded on. This information could possibly be listed in the appendix where similar types of information are now listed.

Table 2.1, Figure 6.7, paragraphs 4.149 - 4.219 and 6.77 - 6.91, and Appendix C of the final have been revised to include this information.

Page 2-104, Paragraph 2.181 - Marshes are discussed only briefly in this section, yet are a primary problem area which may be associated with Corps management activities as indicated in the probable impacts section. The quantity, quality, locations and values of primary marsh areas would benefit

Tables D.1 - D.4 (Appendix D) and paragraphs 2.222 - 2.242 and 4.189 - 4.217 of the final have been revised to include this information.

the existing description. This element would particularly benefit from the establishment of trends which would identify future impacts.

Page 2-119, Paragraph 2.201 - Waterfowl are also susceptible to environmental purturbations. *Aquatic fauna, especially waterfowl, should be discussed in more detail.*

The subject of waterfowl is discussed in paragraphs 2.160 - 2.161 and 4.213 - 4.21 of the final statement.

Section 3 - Relationship to Land-Use Plans and Policies

This section should be renamed to indicate that the section now deals primarily with types of effects and relationships of the Corps actions in conjunction with existing land use and secondarily with the relationship to land-use plans *and policies. However, as indicated below, increased emphasis on land use plans* and planning and future land uses should be established.

Section 3 is named and developed in accordance with CEQ guidelines as presented in Volume 38, No. 147 of the Federal Register. The purpose of this section is to discuss how the proposed action conforms or conflicts with the stated objectives and specific terms of existing or proposed Federal, State, and local land use plans, policies and controls, if any, for the area affected. No conflicts were found to occur. The General Remarks portion of Section 9 discusses the project's relationship to current land use planning.

Page 3-1, Paragraph 3.02 - The two numbered items listed as distinct land-use impacts are not impacts, although they may cause either beneficial or detrimental impacts to various uses of water and adjacent land areas.

Concur. Dredged material disposal and flow regulation are project activities and not environmental impacts. Text has been revised.

Pages 3-1 to 3-3 - The "Types of Effects" and "Existing Relationships" subelements are confusing. The type of management causing land use impacts should be identified with a following explanation of the land use impacts. The distinct land-use impacts and indirect effects contained in both elements should be explained.

The referenced subelement headings are considered to be satisfactory for their intended purpose. The requested information was summarized within the referenced sections. Identified impacts for specific operational management activities were detailed in Section 4 of the draft.

Page 3-3, Paragraph 3.10 to 3.12 - Portions of these paragraphs describing existing and future land use plans and policies should more appropriately be listed under the "Coordination With Existing Plans" subelement. Also, the statements which infer that no changes in economic development above normal growth patterns are expected or changes in land use policies affecting land development are required are incorrect. The ECWRPC is currently developing land use plans and policies which may identify growth patterns other than the extension of existing growth trends.

We do not concur that the subject paragraphs would be more appropriately listed under the *"Coordination With Existing Plans" subelement. We believe that all* of the statements contained in these paragraphs are correct. The apparent statements in question specifically refer only to the relationship between the proposed action and existing land use plans and policies and normal growth patterns already established. The possible consequences of future changes to land use plans and/or project operation and maintenance activities are discussed in other sections of the statement.

Page 3-3, Paragraph 3.12 - There may be trends associated with existing operations and management which will have either detrimental or beneficial impacts on land or water uses in the future.

Comment noted. However, the purpose of the subject statement is to note that existing conditions and relationships are not expected to change as a result of the project action as proposed.

Page 3-3, Coordination With Existing Plans - Under this subelement, local planning activities should be recognized such as '208' and '209' mentioned earlier, and '303e' state planning within the project area. The outcome of *these planning programs may have a major effect on the Corps current management policies.*

Concur. See paragraph 3.16 of the final.

Section 4 - Probable Impacts of the Proposed Action on the Environment

A general comment concerning this section refers to the detrimental and beneficial impacts listed within the various subelements. Although the major impacts associated with the project are briefed individually in the "Summary" at the beginning of the report, impacts listed within the subelements are hard to identify and should be more clearly defined.

The format and organization of this section is consistent with other sections of the statement. The first level of organization in Section 4 addresses the major project components: dredging, dredge material disposal, lock operation and maintenance, navigation, dam operation and maintenance, etc. A second level of organization describes the major identifiable impacts within each of these categories. Subheadings are used as necessary to make still further distinctions of impacts. This organizational format has however been modified somewhat in the final statement through the extensive use of environmental impact tree diagrams and paragraph subheadings which correspond to the elements shown in these diagrams.

Page 4-1, Paragraph 4.01 - There are a number of general impacts associated with the Corps project which have compounding effects. For example, the Corps navigational management practices influence the trends in power boating by increasing boating opportunity. This increase in opportunity has beneficial impacts in the area of recreation and business, but has detrimental environmental impacts such as shoreline erosion and pollution.	Concur. However, this introductory paragraph was not intended to be all inclusive with respect to project impacts, cumulative or otherwise.
Page 4-1, Paragraph 4.03 - Spawning of rough fish and various panfish now takes place in various areas of the Lower Fox. If improvements in water quality in conjunction with federal standards calling for fishable and swimable waters before 1983 are met, fish populations should increase in the Lower Fox.	The final statement has been modified accordingly.
Page 4-1 to 4-4 - Dredging and snagging may increase the need for additional dredging and snagging, i.e., increased bank erosion. Dredging and snagging may also have beneficial effects on flooding conditions on the Wolf River.	Dredging and snagging effects on bank erosion and flooding conditions in the Wolf River area were discussed in paragraphs 4.12, 4.64, and 4.103 of the draft statement.
Section 5 - Probable Adverse Effects Which Cannot Be Avoided This section deals with adverse impacts which cannot be avoided under present conditions. If this section is intended to include social and economic impacts as well as environmental, it is clearly inadequate.	Section 5 is intended to briefly summarize in one place those effects presented in Section 4 that are adverse and unavoidable und - the proposed action. This section reflects the fact that the significant adverse effects (both direct and indirect) of the proposed action are primarily of an environmental rather than socio-economic nature.
Section 6 - Alternatives The discussion on major alternatives to the existing project seems to assume that existing institutional, economic, and social conditions will remain the same and therefore major management changes are basically unfeasible. While this may be true, major improvements in certain environmental and socio-economic problem issues may dictate major management changes. However, the major changes discussed, including abandonment of the navigation system, abandonment of the dam system, and transfer of the operation's responsibility, are only discussed within the context of the Corps responsibility and management operations. This viewpoint is rather narrow, only relating to a portion of the factors which would dictate water and land management within the project area. In order to fully evaluate these management alternatives, a much more comprehensive study of the area would have to be made; some type of reference to this fact should be included within the discussion of the major alternatives.	The purpose of this statement is to address the impacts related to the specific proposed Federal action. A detailed evaluation of overall basin land and water resources problems and needs is not within the scope of this statement. Such an evaluation will be accomplished in the previously referenced Fox-Wolf Basin Level B study. Appropriate findings of this and other related on-going planning studies will be included in a future update of this final statement. No assumptic has been made that existing environmental institutional, economic and social conditions will remain the same.
Page 6-1, "Abandonment of the Lower Fox River Navigation System" - Subelement 6.07 concludes that the abandonment of the lock system would have beneficial environmental effects and detrimental social (recreational) effects. Although many detrimental effects are described in subelements 6.02 to 6.06, no beneficial effects are explained.	Paragraphs 6.03 and 6.05 of the final have been revised to include this informati
Page 6-4, Paragraph 6.14 - Abandonment of some less used locks may be another alternative.	Paragraph 6.08 of the draft statement referred to this subalternative to total abandonment of the lock system.
Page 6-4, "Abandonment of the Lower Fox River Dams" - A number of socio-economic problems with dam abandonment are stated although little or no reference is made to the environmental benefits of dam removal.	The primary environmental advantages associated with dam abandonment were discussed in paragraph 6.16 of the draft. While various other environmental changes would occur, it is less clear in these instances as to whether the resulting change could be considered environmentally advantageous. For example, the aquatic system would change from a lake environment to a stream condition. Also, the matter of the dam abandonment alternative was not addressed in greater detail because implementation of this alternative would have such a drastic impact on the present socio-economic and environmental setting that it is considered to be a highly undesirable alternative.

Comment	Response
Page 6-6, "Alternatives Within the Present Project" - This section, which considers no major management changes, should possibly be renamed to state "mitigation measures within the present project". This section could also be greatly expanded upon in all three subelement groups, which include dredging, dam operation and lock operation, to include additional mitigative measures. For example, under lock operation, changes in the days and hours of operation could be discussed.	Remedial, protective and mitigative measures were discussed in paragraphs 4.75 - 4.105 of the draft statement. No major management changes within the present project are considered possible for the various reasons stated throughout the section. The evaluations of the various reasonable management alternatives within the subject sections have however been expanded upon in the final. Provisions for lockage service (normal and available additional lockage times) were discussed in the Appendix B discussion of navigation regulations for the project.
<u>Section 7 - Relationship Between Local Short-Term Use of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity</u> This section attempts to balance the short-term use of the environment against the long-term productivity within the existing management operations. It would be beneficial to include a discussion of alternatives and mitigation measures to relate potential benefits and problems of these items over the short and long run. For example, the value and role of wetlands in the ecological system is being increasingly recognized and greater preservation or management may be feasible in the future. This section could also relate existing plans and programs and potential technological advancements and their effects in long-term impacts.	According to Section 1500.8(a)(6) of the CEQ guidelines, this section should contain a brief discussion or summary of the extent to which the proposed action involves trade-offs between short-term environmental gains at the expense of long-term losses, or vice versa, and a discussion of the extent to which the proposed action forecloses future options. We believe that Section 7 accomplishes this objective.
<u>Section 8 - Irreversible and Irretrievable Commitments of Resources</u> As indicated on page 8-1, paragraph 8.01, a number of resource commitments were identified in previous sections of the report. However, all of these commitments have not been identified in this section and a description of these implications stated. Both Section 8 and Section 7, which should provide a discussion of critical issues for analysis by decision-makers, seemed to have fallen short of their purpose.	Section 8 is limited to a summary discussion of the uses of resources, changes in land use, unalterable disruptions in the ecosystem, and other unavoidable effects identified in Section 5 which would irrevocably curtail the diversity and range of beneficial uses of the environment.
<u>Summary Comment</u> A number of important issues and problems were identified in the Environmental Statement. An important result of this data and analysis should be recommendations of areas for further study. This would include areas in data deficiency, need for additional technical studies, and need for legislative action. These recommendations could be documented from the contents of this statement for the use in initiating further action. It is, however, unclear in which section of the Environmental Statement these recommendations should be stated	Neither the draft or final impact statements contain any recommendation which would significantly alter the current project status. Any proposal to abandon or substantially modify the project would require considerably more detailed study and authorization by the Congress. This type of study is beyond the scope of the current environmental impact study and no such study is planned at the present time. Any further detailed investigation relating to the status of the Fox River Federal project would not be undertaken until the current regional 208 water quality and Level B Basin studies are completed. The major purpose of these important studies is to determine the desires and needs of people within the region for conservation, development and utilization of water and related land resources, and to identify and recommend action plans and programs to be pursued by Federal, State and local agencies. At the completion of these studies, the Chicago District will be in a better position to reevaluate the Fox Project within the context of overall regional needs and the public interest.

COUNCIL-MANAGER ADMINISTRATION

March 19, 1976

Colonel James M. Miller
District Engineer
Department of the Army
Chicago District, Corps of Engineers
219 South Dearborn Street
Chicago, Illinois 60604

Dear Colonel Miller:

I am writing in follow up to your publishing of the Draft Environmental Impact Statement relating to the Operation and Maintenance of the Fox River, Wisconsin Navigation Project and, more specifically, to request that the Corps of Engineers consider removal of obstructions to recreational boating in the Fox River in the City of Oshkosh.

As you note in the EIS under items 4.22, 4.23 and 4.24, the present usage of the Fox River and Lake Winnebago pool revolves almost entirely around recreational traffic which, in turn, is an economic plus for the communities adjacent to this waterway. Your present operation and maintenance program within the area consists of dredging of channels to permit recreational traffic to utilize the river and lakes including harbors of refuge. Within the City of Oshkosh limits, a channel of six (6) foot depth is maintained for this purpose.

The obstructions referred to above consist of wooden pilings in the area of the Paine Lumber Company on Congress Avenue, Park Plaza at Jackson Street and Riverside Cemetery along S.T.H. 110. Although many of the pilings are visible above the water surface, many are also submerged and create an additional hazard for boating traffic.

The City would ask that you consider removal of the pilings or cutting them off six (6) feet below surface level as part of your continuing maintenance program of the Fox River and Lake Winnebago pool. Additional information regarding exact location, number, etc., will be furnished upon request. We will further, be available to make a site inspection of these areas at your request.

I would appreciate a response at your earliest convenience.

Sincerely,

DAVID L. WENDTLAND
Acting City Manager
City of Oshkosh

The Chicago District has no authority to remove the subject pilings under the operational and maintenance program for the Fox Project because these pilings are not an authorized feature of the Federal Project. The Corps of Engineers may have authority under Section 3 of the River and Harbor Act of 2 March 1945 to investigate and undertake the removal of accumulated snags and other debris in the interest of navigation. By letter dated 28 March 1977, the City of Oshkosh requested an investigation into piling removal under the Section 3 authority. By letter dated 12 April 1977, the Chicago District indicated that such a study would be undertaken as the District's workload permitted. A Section 3 investigation would have to very carefully consider the views of the Wisconsin Department of Natural Resources. This agency is known to oppose removal of the pilings. The DNR has indicated that the pilings are used intensively during the spawning season by yellow perch. The remaining alternative provision of navigation aids is a U. S. Coast Guard responsibility. It is the apparent position of the Coast Guard, however, that marking the pilings with aids to navigation would be ineffectual because they are so numerous and widely dispersed. Marking the pilings would also have to be continued indefinitely, whereas complete removal of the pilings would involve only a one-time expenditure.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Anthony S. Earl
Secretary

BOX 450
MADISON, WISCONSIN 53701

IN REPLY REFER TO: 1600

April 30, 1976

Colonel James M. Miller, District Engineer
Corps of Engineers, Chicago District
219 South Dearborn
Chicago, Illinois 60604

Dear Colonel Miller:

Re: Draft Environmental Impact Statement, Operation and Maintenance of the Fox River Navigation Project in Wisconsin

At the request of your Environmental Resources Branch, we submit the following review comments on specific paragraphs of the Fox River D.E.I.S.

Page ii - (2) - *Dredging may also remove spawning* shoals, and drift material could clog riprap areas sufficiently to make them unattractive to sturgeon.

Paragraph 3A(2) of the summary statement has been modified accordingly.

ii - (7) - This section fails to acknowledge downstream impacts of dam operation. For example, operation of the control dams could cause scouring downstream by passing excessive volumes of water during normally low periods.

As noted in paragraph 4.65 of the draft, the flow through the Lower Fox River is maintained *fairly constantly except for periods of peak upstream runoff.* Scouring of accumulated sediments in these channels is generally limited to periods of high stage and flow. The unavoidable impacts which occur under these circumstances are considered to be relatively minor compared to the other items cited in the summary.

Paragraph

1.02 The de-authorization of the upper Fox River could be listed in this series of legislative references.

The paragraph has been modified accordingly.

1.04 The last sentence could indicate that the Upper Fox River was declared not to be a navigable water of the United States by Congress.

It is true that with the transfer of the Upper Fox to the State of Wisconsin that the Upper Fox ceased to be a navigable waterway in a commercial sense, and that the Corps of Engineers no longer exercises Section 10 regulatory authority over it. However, the precise definitions of "navigable waters" or "navigability" *are ultimately dependent on judicial interpretation and pursuant* to judicial interpretation of Section 404(b) of the Federal Water Pollution Control Act Amendments of 1972, P.L. 92-500, the Corps of Engineers continues to exercise regulatory authority over the waters of the Fox River.

1.11 The exact location of the "preselected disposal sites" must be presented. Only then can we evaluate the impacts of dredge spoil disposal. When the Corps provides maps showing the exact locations, field reviews of each site will be conducted by our staff.

Maps showing the specific location of the preliminary disposal sites proposed in the draft statement were forwarded to the Department of Natural Resources by letter dated 7 May 1976. With the subsequent cooperation and assistance of the Department, a final disposal plan was developed and agreed upon. This plan is described in Table 1.5, Figures 1.4 - 1.16, and paragraph 1.26 - 1.29 and 4.65 - 4.116 of the final.

1.20 As you are aware, Wisconsin is opposed to open water disposal of dredge spoil regardless of the degree of "pollution." Operating practices and engineering plans for confined disposal should be presented for the projects outlined in Table 1.3.

The recommended disposal plan features containment of polluted dredgings, transportation of dredged material to inland areas in need of fill or restoration, and disposal of project dredgings on agricultural lands. A major dredged material disposal problem, yet to be resolved, involves open water or in-lake disposal of unpolluted dredged materials. Until this matter is resolved, disposal operations will be limited to state approved disposal sites. Operating practices and engineering plans for confined disposal are discussed within Section 4.75 - 4.116 of the final.

Table 1.3 - We question whether there is sufficient area for 25,000 cubic yards of spoil along Boom Cut without in-lake disposal.

It is true that dredgings from Boom Cut *could not be entirely accomodated along* the existing dredge bank without some in-lake disposal. For this reason, dredging and disposal operations at this location will be suspended until the question of in-lake disposal of unpolluted dredgings is resolved.

Paragraph		
1.24	We seriously doubt the need for "Harbors of Refuge" for craft requiring six feet of water. Existing harbors of refuges should be available only to the smaller 10-16 foot craft. These could be maintained with considerably less dredging.	Periodic maintenance dredging and disposal would still be required to a lesser depth. It must also be noted that even boats whose lengths are in excess of 16 feet may be endangered by occasional storm events on Lake Winnebago (See paragraphs 6.25 - 6.26 of the final). Class 1 (16-26 feet) and Class 2 (26-40 feet) recreational craft typically have corresponding drafts of up to 1.85 and 2.9 feet, respectively. Allowance for squat of 1-foot and 1-foot for clearance increases the minimum water depth required for normal boat operation. Sailboats, large vessels, and Corps dredging equipment require the full project depth.
1.28	Severe fluctuations in water level are much more common and extensive than are indicated in this report. Even if the legal limit is not exceeded, severe fluctuations during the spring and summer months can be damaging to vegetation. The "legal limit" of 3.45 feet on the Oshkosh gage was set in 1886 without much thought being given to its effect on the wetland habitat. It is an artificial standard, therefore, without a biological basis and is not necessarily right for maintaining a satisfactory wetland environment.	Considerable variation in lake levels occur throughout any given calendar year. The impacts associated with these water level fluctuations are described at length in Section 4 of this report (See paragraphs 4.189 - 4.217). We agree that the legal limit of project regulations is somewhat of an artificial standard and, as such, may not necessarily be right for maintaining a satisfactory wetland environment.
	The report indicates that the legal limit was exceeded in only 15 instances and then only for short periods. What is considered a short period? During May of 1960, the legal limit was exceeded for 28 days. Also in 1960, the limit was exceeded on the 25th of April and twice during the early part of June and once more in the latter part of June. If a gage reading of 3.00 feet is considered as high water (but still within the legal limit), high water existed from the middle of April through the first week of September in 1960. Average high-water for the entire period of record from 1896-1964 was about 2.85 feet so it appears that 3.00 feet could be considered as high water. There are other years when high water prevailed for protracted periods even though the legal limit was not exceeded. High water of this sort can be extremely damaging to aquatic vegetation.	Table C-1, Extreme Annual Levels of Lake Winnebago, 1950 - 1975 shows that the upper limit of regulation was exceeded for a total of 32 days in 1960 and again for 21 days in 1969. These two occurrences represent extreme situations when regional meteorological conditions were such that flood inflow greatly exceeded maximum possible outflow. Reference to the upper limit having been exceeded in only 15 cases and then only a few inches for a short period has been deleted because of the subjectivity of the statement. The impacts of high water on vegetation are discussed in 4.161 - 4.168 of the final.
1.33	Are the boating interests, which are so very vocal, representative of the boat owners as a group or are they a loud minority within that group? Those who have the greatest need for high water levels are owners of large craft. These people, according to this report, make up a very small segment of the boating public (Pg. 2-85, par. 2.137). They probably are the ones who are making the most use of the locks, and they would then be in the ones who are costing the Federal Government $97.00 per boat per year in locking costs (Pg. 4-7, par. 4.25). This amounts to a considerable subsidy for a minority group.	These comments basically relate to the benefit/cost justification of project water level management and lock operation expenditures for navigation purposes. As stated in paragraph 4.26 of the draft, however, it is not impossible to draw valid conclusions regarding these questions on the basis of presently available data. Additional study is required on these questions.
2.02	If the Winnebago Pool is to be defined as the backwater of the Neenah-Menasha dams, then the pool extends as far as Fremont since Partridge Lake is slightly affected by operations of those dams.	Although the backwater effect of the Winnebago Pool may extend up to Fremont, the three regional subdivisions cited in this particular paragraph were established on the basis of physiographic features not hydrological ones.
2.06	The maximum depth of Lake Winnebago is misleading since most of the lake is considerably shallower than 21 feet. An average depth figure should be included to point this out.	Paragraph 2.06 has been revised to include this information.

Comment	Response
2.06a A reference should be provided on the law which established the operational range during the navigation season. The request of the DNR does not represent a formal agreement as implied. The informal agreement entered into by a DNR staff member should not be taken as an official Department position. We suspect that the scope of the agreement dealt with the April 1 level and not the draw down of 18 to 24 inches below the Menasha dam. The history of operations under this informal agreement should be documented. We also note that although the Corps' reconstruction of the Menasha dam did not raise water levels in the Lake Winnebago Pool, the original dam did raise water levels approximately 3 feet (Oberton, 1935).	Section 4 of the River and Harbor Act of 1894 is the basic authority pertaining to regulation of Lake Winnebago. The upper limit of regulation was established by the 9 October 1886 Marshall Order. The lower limit of regulation was set by rules and regulations issued under date of 5 February 1895. The original construction of the Neenah and Menasha dams is believed to have raised the original water level of Lake Winnebago by 2 feet (House Document No. 146, 67th Congress, 2d Session). The agreement cited in this paragraph was intended to refer to an offcial Wisconsin Conservation Department request to have the level of Lake Winnebago at or above the Menasha dam crest by 5 April. Copies of correspondence concerning the history and documentation of this request have been included in Appendix D of the final. For reasons stated elsewhere in this statement, modification of this policy is recommended.
Table 2.5 - We believe the dissolved oxygen range at Freemont should be 4.2 to 13.4.	This table has been revised to correctly show the minimum dissolved oxygen at Freemont at 4.2 ppm.
Paragraph	
2.26 What is the definition of "hypereutrophic?" This is a strong statement when describing Lake Butte des Morts.	Professor William C. Sloey, Department of Biology, Wisconsin State University, Oshkosh, Wisconsin, has classified this lake a hypereutrophic. The Federal Environmental Protection Agency National Eutrophication Survey classified this lake as very eutrophic. It is the latter terminology which has been used in the final statement.
We agree that the decay of dead algae does not create a serious oxygen demand. However, industrial concerns would not concur with this observation.	Comment noted.
2.30 Our auto-monitor at Menasha frequently records supersaturation of oxygen; however, the fluctuations are rather extreme. Flow augmentation to improve Lower Fox River water quality would create even larger lake level fluctuations than at the present.	Comment noted.
We are aware that the Corps will be an active participant in the Great Lakes Basin Commission's upcoming Fox-Wolf River Basin Level B study. That study will be addressing many of the resource use conflicts highlighted by this Draft E.I.S.	Comment noted.
Table 2.8 - The permitted average daily loadings for the George A. Whiting Paper Company, which was omitted from the table, are 272 Kg/day (600 lbs/day) BOD_5 and 725 Kg/day (1600 lbs/day) suspended solids.	The requested addition to this table has been made.
Table 2.9 - We assume that one of the NO_3-N values should be NH_3-N.	The necessary correction to this table has been made.
Paragraph	
2.34 The levels of mercury in the sludge deposits and sediments ranged from .34 ppm to 3.6 ppm. These levels of mercury are too high *to allow open water disposal of dredge spoils. Confined disposal* could contribute to the eventual removal of mercury from the system since the major source of mercury (paper mill slimicides) has been discontinued.	Open water disposal of polluted dredgings from the Lower Fox River has not been proposed. Section 4 has been revised to note that a beneficial impact of project dredging on the Lower Fox River is the contribution that project dredging and associated land disposal afford in the removal of mercury from the water system.
Figure 2.5 - The key designating the "Observed" data should be placed in a legend box so that it doesn't appear to be part of the actual data being reported.	The subject figure has been deleted from the final statement.

Comment	Response
Figure 2.13 - The second keyed symbol should be titled "Ground Moraine."	This figure has been corrected.
Paragraph	
2.86 Trout streams are not "registered", but are merely "listed" in the DNR's Publication 6-3600(74) - Wisconsin Trout Streams.	Text has been revised as requested.
2.114 Some discussion of the historical aspects of the River itself may be in order.	Concur, paragraphs 2.173 - 2.189 of the final statement have been revised to include this information.
2.146 Waushara County borders on Lake Poygan, a part of the project area, and local officials would definitely have an interest in the operation of this project as it affects fishing.	Comment noted.
2.149 Does the Lake Winnebago area have a duck hunting season "unequaled" anywhere in Wisconsin? Citing a 1960 report (16 years old) does not necessarily mean it's true today with depleted redhead and canvasback populations (see par. 4.62).	Concur. The statement has been deleted. The decline of waterfowl in the Lake Winnebago area is discussed in paragraph 2.161 of the final.
2.152 Ice fishing, and especially sturgeon spearing, are major forms of winter recreation in the project area.	This is noted in paragraph 2.166 of the final.
2.154 No data are presented to indicate that more marinas and launchways existed in 1975 than in 1968.	The Striegl data published in 1968 represents the *last* comprehensive survey of facilities in the region. In view of the marked increase in regional boat ownership; however, it is reasonable to assume that more marinas and launchways existed in 1975 than in 1968.
2.156 There is substantial fishing use of Lake Winnebago in June on the reefs after the walleye return from the spawning run. Recreational boaters are a major contributing factor to the reduced number of fishing boats on the river during the summer.	The referenced paragraph was intended only to show the seasonal variation in the pattern of boat usage. Although pleasure boating undoubtedly impacts on fishing activity to some degree, the significance or extent of this adverse impact is unknown.
2.159 This statement is in error - 26-40 foot boats may be popular recreational craft but are not the most popular "fishing craft." Table 2.33 shows DNR data which do not seem to support the statement in the text.	The data from the sources cited in Table 2.33 of the *draft statement* support the conclusion that Class 2 boats (26 to 40 feet) are the most popular fishing boats on the lakes in the upriver area during the May fishing season. The DNR data only *applies to* Wolf River area fishing boats during the May fishing season. As noted in other paragraphs of the draft statement, boat class patterns change during the 1 May to 1 November navigation season.
2.172 What is meant by "....dam pool can become stagnant...?" Is Lake Winnebago stagnant? A definition of terms is needed.	The statement refers to slackwater pools created by the dams along the Lower Fox River. The final statement has been revised to clarify this point.
2.173 Complaints are commonplace each year (1975 being an excellent example). A conference held February 13, 1975 at Oshkosh to discuss Lake Winnebago problems resulted in nearly 10% of the people present stating that water levels are a definite and major project on Lake Winnebago (some 100 people were present).	Considering the complexities of lake regulation management and the number of affected interest groups, "relatively few complaints have actually been received by this office over the years. However, due to the subjective nature of this remark it has been deleted from the final statement.
Paragraph 2.06a indicates that only the summer operational range is regulated by law. It appears that the *winter operations* could be easily altered to improve habitat conditions while not significantly affecting other interests.	The phrase "the former limits are established by law" referred to the upper and lower limits of regulation for both the open and closed navigation season. The constraint that lake level be brought up to dam crest by the first week in April, rather than 1 May, is an administrative action taken at the request of the DNR in 1958. In early ..6, the DNR area office at Oshkosh (see Appendix D) proposed a continuation of the long establish d winter drawdown procedure and a restoration of pool level to dam crest by 30 April rather than the first week in April in order to minimize adverse water level impacts on lake habitat. This proposal would alter the 1958 administrative action adopted at the request of the DNR. The Chicago District would be willing to return to the original operating procedure if officially requested by the DNR.
The decrease in the size of Supple's Marsh is not as great as indicated. Much of the landfill operation has taken place on upland.	The remark in question (paragraph 2.181 of the draft) only indicates that Supple's Marsh is much smaller today as a result of past landfill operations. Aerial photographs o. the area show this to be so. The specific acreage loss was not indicated.

2.181 Data from our submergent vegetation transects during the summer of 1975 indicate that Lake Poygan has the best stands of submergents. In this lake, wild celery is the most abundant submergent followed by coontail, narrow leaf pondweeds, sago pondweed and Najas spp.--in that order. Transects in the other lakes show mostly sparse growths with sago, coontail, Najas spp. and wild celery being the most common species. Coontail and sago are dominants. Potamogeton nodosus was not collected on any of the transects. It would appear that there may have been a qualitative shift in submergent vegetation since the lakes were surveyed by Harriman in 1968. Potamogeton nodosus is no longer a "most important rooted aquatic."

Comment noted, see revisions to paragraph 2.226.

Sagittaria latifolia is not the most important species of arrowhead in Lake Poygan. Apparently, this statement is based on Harriman's report, but Harriman's material must have been erroneously copied since he indicates that Sagittaria rigida is the most abundant sagittaria. It is able to tolerate deep water and Sagittaria latifolia is not. Our data confirms Harriman's findings.

American lotus is protected but is not considered an endangered species. Lotus beds are not found in Lake Butte des Morts proper, except possibly for a small patch in the extreme southeast corner. Beds are located in the Fox River at Rivermoore, near the mouth of Dagget's Creek, and in Spring Brook near the bridge. We have not seen the bed mentioned in this report off Clark's point in Lake Winneconne. Harriman does not mention this bed in his report either.

Because of changed conditions and/or possible discrepancies in reported observations specific references to sited occurrences of american lotus have been omitted from the final.

Table 2.41 - Conditions and vegetation have changed since this list was compiled.

The subject table contains no reference to frequency of occurrence or species abundance. The species listing and habitat preference data provided in this table is reasonably current and presumed to satisfactorily reflect current conditions and vegetation for the purposes of this report.

Paragraph

2.190 While no endangered reptiles or amphibians are listed, information sent previously indicates some species are being watched to ensure their continuing viability.

Paragraph 2.251 has been revised to include this information.

2.196 Bird use should not be attributed to the presence of the spoil, since in some locations, such as the Boom Bay Cut, the banks make up an insignificant part of the habitat. Many of these birds would be present without the spoil banks.

The subject paragraph did not attribute bird use to the presence of dredged material. It merely served to show that past disposal practices have had little apparent effect on bird species composition and that the species found were representative of the succession stage habitat that existed at previously used sites.

2.199 The Wolf River as it empties into Lake Poygan is not clean but often contains large amounts of suspended clay. Aerial color photography shows this quite clearly. Our sediment sampler located in the Boom Cut collected sediments which were 89% inorganic material.

Comment noted, see revision to paragraph 2.260.

Table 2.49 - Reference "b" should read "J. R. McKersie,..."

Correction noted, see revised Table 2.37.

Paragraph 2.212 - A discussion of Diptera needs to be included in this paragraph.

The subject paragraph is considered to be satisfactory for its intended purpose.

2.219	The spelling of the DNR staff member's name is "Morrissette."	Correction noted.
2.230	Our records indicate a 1955 harvest of 1,505 sturgeon from Lake Winnebago and 581 from Lake Poygan.	Correction noted.
2.248	We question where cisco would be found other than in Green Lake.	Correction noted.
Page 2-144, reference 20 - The author's name is Patterson.		Correction noted.

Paragraph

4.03	No evidence exists to indicate that spawning will not be affected. The Lower Fox River does support a fishery as best evidenced by the perch fishery on Little Lake Butte des Morts. Our investigations in 1975 revealed that 24 species of fish inhabit the Fox River between DePere and the Little Kaukauna Dam. No doubt several of them spawn successfully.	The sections of the Lower Fox waterway that most frequently require maintenance dredging are the approaches to the locks and two restricted river channel areas. In view of the limited size, location and physical characteristics of these sites, the possibility that any fish spawning grounds will be affected is remote.
4.05	The proposed disposal sites for Wolf River snags, debris, and spoil material should be presented for field evaluation.	Concur. See paragraph 4.89 of the final.
4.06	Unless firm data could be presented to show that competition and predation are the controlling factors in fish survival, it would be safe to assume that destruction of spawning habitat would have an adverse effect on recruitment. The adverse effects of channel snagging on fish populations have been documented by Gary Hickman in his studies of the Middle Fabius River in northeastern Missouri.	Paragraph 4.50 of the final has been modified accordingly. It must be noted, however, that spawning success is influenced by the number, size, and condition of available spawning areas. Even if spawning failed in some areas, sufficient successful spawning would always occur at other locations, since so many large and high quality spawning sites exist on the Wolf River.
4.07	Dredging at four year intervals may not allow sufficient time for the re-establishment of spawning habitat and sufficient recruitment to maintain the fish population through the next dredging cycle. If this pattern continues for 20 years, significant declines in fish populations may result.	Periodic maintenance dredging and snagging operations have been performed over a 25-mile portion of the Wolf River for the last 80 years without an apparent significant decline in area fish populations. Because dredging locations and quantities to be dredged are so variably, dredging and/or snagging operations at one given location are substantially in excess of four year intervals.
	This paragraph also documents the futility of dredging in the river environment. Continued deposition of sediments and the resultant need to dredge is an illustration of treating the problem without attacking the cause. It would appear that a shift of Federal priorities from dredging to erosion prevention would go a long way in reducing the need to dredge and the associated problem of spoil disposal.	Federal program priorities and expenditures are already heavily to erosion prevention. The Agricultural Stabilization and Conservation Service has funds available for cooperative ventures with agricultural land owners to deal with erosion problems. However, these programs depend on the willingness of land-owners to cooperate and some of the more severe erosion problems are in non-agricultural parts of the region and a broader focus of Federal legislation in connection with erosion problems would seem to be desirable. If indeed the rate of upland erosion is reduced then the amount of maintenance dredging and snagging may also be reduced. Nevertheless, it must be noted that the Corps maintenance dredging and snagging program on the Wolf River is a very minor one, that present channel maintenance is in large attributable to flooding and other natural phenomena, and the Corps of Engineers does not have the authority to undertake the suggested erosion control programs.
4.10	It is difficult to assess the impacts of dredging and spoil disposal on water quality when no estimates of discharge rates and effluent quality from disposal areas are given. It would also be helpful to have sediments tested for PCB's and cadmium.	The discussion of the impact of dredging and disposal on water quality has been greatly expanded upon in the final statement (See Sections 4.20 - 4.32 and 4.110 - 4.115). In an effort to obtain a more precise quantification of dredging and disposal effects on water quality, a monitoring program has been proposed (See paragraph 4.252 of the final). Future project sediment sampling will include testing for PCB's and cadmium.
	Statements such as "Dreding of these sites is not desirable..." raises questions on why it is being done when no attempt has been made to really justify the continued operation of the project? This paragraph points out the need to seriously reevaluate the Federal commitment to the present project.	It is not the purpose or function of the environmental impact statement to justify the proposed Federal action. The dredging, while not necessarily desirable from a purely environmental standpoint, is necessary to maintain navigation on the waterway system. The final sentence in the subject paragraph concludes by saying that the resulting unavoidable adverse impact will be short-term and that no significant long-term environment impact is expected to occur. The subject of the Federal commitment to the present project is discussion in paragraph [illegible] and the General Remarks portion of Section 9 in this document.

Paragraph	Comment	Response
4.12	**Would flood elevations increase due to the deposition of spoil material in the floodplain?**	The transfer of dredged materials from the channel to the floodplain does not reduce stream flood carrying capacity and may, in fact, actually increase the total flood carrying capacity. The channel has a greater efficiency for conveying flood flows then the overbank (floodplain) areas, i.e., a greater amount of water (cfs) per square foot of cross-sectional area can flow in the channel than in the overbank. Thus, the total flood carrying or conveyance capacity of the channel and overbank cross section will be increased in those instances where dredged materials are disposed in the floodplain.
4.13	**The description of the disposal sites is totally inadequate to assess impacts associated with the disposal sites. Open water disposal would be environmentally unacceptable.**	Subsequent to the issuance of the draft statement a multi-agency field inspection of Corps proposed disposal sites was held. The resulting site assessment comments of the Wisconsin DNR are reflected in paragraphs 4.77 - 4.89 of the final statement. Open water disposal is not a feature of the project disposal plan.
4.14	**The farm field swales may in fact be Class II wetlands. As such, we would favor their preservation as waterfowl habitat. Detailed maps of these areas are needed before we can assess the merits of preserving any individual site.**	Disposal will not be undertaken in any wetland or marshy portions of farm property. Individual disposal sites will be subject to Federal and State reviews and approvals.
4.15	**The Corps should be aware that the owner or operator of the four confined disposal sites must apply for a WPDES permit at least 180 days in advance of any anticipated discharge. This requirement would also apply to those onshore sites that are adjacent to water bodies and from which there may be a discharge.**	The only proposed direct discharge to a water body from a confined disposal site occurs at Little Kaukauna as described in paragraph 4.78 and shown in Figure 1.6 of this final. Although the United States Supreme Court has ruled the WPDES permit requirements do not apply to Federal agencies, the Chicago District will coordinate the final detailed engineering and operating plans for this site with the DNR and informally comply with such other reasonable requests as may be appropriate.
4.19	**This section should point out that the filling of wetlands on private lands is proposed.**	Filling of wetlands, private or otherwise, is not proposed.
4.20	**Until the exact fill sites are known, the value of wetlands to be destroyed cannot be assessed.**	Filling of wetlands is not proposed. The DNR will have an opportunity to review and evaluate currently unspecified sites as actual fill areas become known.
4.25	**Although the method used to calculate the number of craft using the system is based on questionable assumptions, we wonder whether the $97 per craft is high enough. This figure does not include all costs associated with the project (par. 8.09).**	The $1 million figure cited in paragraph 8.09 in the draft is the total cost for operating and maintaining the entire Federal project. The $97 cost per craft per year using any part of the lock system was based only on the portion of the overall total cost attributable to lock operation and maintenance, and maintenance of the Lower Fox River channel.
4.33	**Added to the list of adverse impacts could be the destruction of marshes and the loss of bottom materials.**	Paragraph 4.161 of this statement contains the suggested revision.
4.34	**High water levels can also retard or eliminate the growth of aquatics by reducing or excluding sunlight.**	Paragraph 4.163 of this statement contains the suggested revision.
4.36	**The 21¼" high is the limit set by Congress, but there is nothing in the law to prevent operation at any level above the spillway level and below this limit. Such an operation would reduce adverse biological impacts.**	Water levels are currently maintained at about 15 inches above the crest of the dam provided that inflows are adequate to maintain this level. This storage benefits downstream municipal, industrial and hydropower interests, as well as upstream recreational boating interests. Also, unless a certain amount of water is available to offset deficient lake inflows during some low water period, navigation is adversely affected. Given current authorizations and the very limited current operational tolerances of lake regulation--inches not feet--it is not considered appropriate to significantly alter the existing lake level management plan at this time. The alternative of maintaining a lower pool level and thereby reduce adverse biological impacts is discussed in Section 6.78 - 6.72 of the final.
4.41	**Again we point out the informality of the 1959 agreement between the Corps and our Department. We affirm that the April 1 level should be reevaluated.**	Same as response to comment on paragraph 2.06a.
Figure 4.1	**- This map has been redrawn adding portions of Lake Poygan not on the original. The west end of Lake Poygan, which is in Waushara County, was not included on our original map because the 1862 map from which it was copied did not cover this area. Mr. Linde's name should not be placed on this map since it was altered by someone else to make the map look more complete.**	The redrafted figure is virtually identical to the original map in all important respects. The purpose of both maps is to provide a graphic representation of the difference in open water area on the upriver lakes between the year 1862 and the present time. Figure 4.8 in the final has, however, been modified to clarify the fact that the original 1862 map did not include an open water surface delineation for the west end of Lake Poygan in Waushara County.

Paragraph	Comment	Response
4.48	This 6-inch recommendation is not an estimate but is based on Corps' record of the water levels in the Winnebago Pool. These data were worked into a line graph which indicated quite clearly that mean summer water levels for the period 1896-1937 had increased approximately 6 inches over the period from 1938-1973. This EIS uses much of the same water level data for these same periods but in bar-graph form to prove that our "estimate" was correct (Fig. 4.2). There is not much question about the effects of high water levels on emergent vegetation in the spring. There are many reports of high water causing bog to break up and float away. Newspaper photos show huge floating islands of aquatic vegetation being dynamited to open blockages in the river which formed at the Oshkosh bridges.	The use of the term "estimate" has been deleted from the text. We agree that the adverse effects of high water levels on emergent vegetation and floating bog are well established. The question posed in this paragraph was to what extent these losses may be attributable to natural flooding and high water as opposed to project-controlled pool level increases over the past several decades.
4.56	According to local trappers, the decline in muskrat populations in the up-river lake marshes has been sizable. There is little doubt that if many square miles of marsh are lost (as happened on these lakes) the muskrat harvest is going to be greatly reduced.	Muskrat harvest and house count data show a large degree of fluctuation over the last 20 years despite the fact that the controlled water levels of the project follow a regular yearly pattern of regulation. This suggests that there must be a number of other important variables influencing local muskrat populations. We agree, however, that continuing marsh vegetation losses will result in a local decline in muskrats and the final statement has been modified accordingly (see paragraph 4.211).
4.58	All mammalian species that normally inhabit marshes in this area must have been affected by a large reduction in the habitat when marshes disappear.	The statement does not indicate that other mammalian species normally inhabiting marshes would not be affected, but rather that the mammalian species of old fields, lowland and upland forest would not be adversely affected by fluctuating water levels.
4.61	Reed grass is not floating and provides no mat for nesting. Nesting takes place in the floating bog which is composed of other types of aquatic vegetation.	The subject paragraph has been modified accordingly (see paragraph 4.215).
4.63	The Red-Shouldered Hawk is on our Threatened list, not on the Endangered list.	Text has been revised accordingly (see paragraph 4.217).
4.68	This is not a true statement. For example, the Fox River Paper Company loses head due to high tailwater elevations which results in reduced generating capacity.	It is true that industrial and municipal uses of river water are unable to utilize the maximum flow of the river during floods. Conversely, hydropower interests are adversely affected because of idle equipment during the low waters of late summer and early fall. High stage and flows, however, permit a more uniform river water supply and increase the overall stream utility for power generation.
Table 4.3,	Wolf River Site - The presence of cattail and broad-leaved arrowhead indicates that wetlands have been filled in the past. Our Department generally opposes wetland sites for spoil disposal.	The presence of cattail and broad-leaved arrowhead does not necessarily indicate that wetland disposal has previously taken place at any of the sites in this table.
5.01	Infrequent dredging of short duration can certainly have significant adverse effects if the spoil is placed in critical areas where it can damage wetlands.	The proposed dredged material disposal plan will not damage wetlands.
5.03	The effects on flood elevations should be predicted.	Flood elevations will not be impacted upon by dredged material disposal operations. These operations do not introduce any new fill into the floodplain.
5.05	Water level control undoubtedly cannot be eliminated without adverse effects to many of the interests concerned, but it can be modified to produce fewer problems to the environment than the present control procedures are having.	Pool regulation procedures could be modified to produce fewer environmental habitat problems upstream of the control dams. It must be recognized, however, that the maximum advantage of lake level management for any one purpose must be compromised so that all of the other interests served by the project are benefited.
6.03	How would lock removal foreclose future reactivation of the existing system? It would just be more expensive.	Abandonment of the lock system but leaving the locks in place would permit the later reactivation of the system should future circumstances ever warrant it. Removal of the existing locks would not afford this same opportunity. Practically speaking, removal of the existing locks would also foreclose the possibility of ever reestablishing a replacement lock system because the construction costs would be prohibitive and would undoubtedly greatly exceed the benefits to be derived.

6.05	What documentation is available to indicate that local interests do not favor operational changes?	Local interest opposition to abandonment of the lock system is based on the adverse effect this action would have on each of the various interests cited in the subject paragraph. This is well documented in transcripts of previous public hearings on the project, written correspondence received by this office, and conversations with boaters, local elected officials, businessmen, community leaders and the general public at various times during the preparation of this report.
6.06	A one time expenditure of money to abandon the project may be cheaper than expending $361,000 per year (exclusive of dam operation).	It definitely would be. However, the final sentence in the subject paragraph merely stated that removal of the lock system would necessarily involve a one-time expenditure of money.
6.09	Our experience with the Upper Fox River would lead us to believe that the DNR would probably oppose taking over the Lower Fox River.	Comment noted.
6.12	There is some question whether or not the state could legally spend money to acquire, operate or maintain this project under the internal improvement doctrine of the state constitution.	A precedent for this alternative was established in the 1962 transfer of the former Upper Fox River portion of this project to the State of Wisconsin.
6.15	The dams do not help water quality as is implied here. While it is true that four of the dams do aerate the turbines and thus contribute oxygen, the very existence of the dams greatly outweighs this effect in terms of water quality.	The questionable reference to a water quality control benefit provided by the dams on the Lower Fox River has been deleted from the final.
	Navigation costs admittedly are high for the benefits derived by a relatively small group of people. However, the Neenah and Menasha dams could probably never be abandoned because of the impact on the very extensive lake shore developments throughout the entire Winnebago Pool and other recreational and economic considerations.	Concur.
6.19	The "large" boats do not really need refuges, and the small boats that need harbors can get by in three feet of water not six. Therefore, dredging could be reduced. Certainly past practices of open water spoil disposal have not been without their adverse impacts.	The adverse impacts associated with previous disposal practices were appropriately discussed in other sections of the statement. Refer also to response to comment on paragraph 1.24 of the draft.
	The alternative of reduced dredging should not be discussed as too economically insignificant to implement. When paragraphs 6.19 and 6.20 are combined, considerable savings could be achieved.	These paragraphs merely stated that discontinuation of dredging at either or both of the subject dredging sites would not result in large economic savings in the overall cost of project operation and maintenance.
6.21	The volume of water which is reflected in the 6 inch elevation increase over the past 38 years should be presented, and its value to hydropower interests should be quantified. Further hidden increases in water levels must be avoided. When the power companies make no contribution to maintaining the dams, they should not be allowed to seek more water at the expense of other interests.	The volume of water reflected in the subject pool level increase represents about 110,000 acre-feet of storage. The value of this storage to power production is indicated by the amount the useful flow during the fall and winter months exceed the inflow into the lake during those months. Data available for several hydro-electric stations on the river indicates that this storage has resulted in an average annual power production increase of over 5 percent of that which would have otherwise occurred. The subject increase is well within the authorized limits of regulation and should not in any way be considered "hidden." The power companies are legally entitled to this surplus water.
6.23	A user toll could be established on a pilot study basis to examine the elasticity of demand. Tolls for recreational craft would be reasonable since recreational use was not a part of the original project purpose and authorization.	Section 4 of the 5 July 1884 Appropriation Act for civil works, as amended by Acts of 3 March 1900; 3 March 1909; and 30 August 1954, states in part: "No tolls or operating charges whatever shall be levied upon or collected from any vessel, dredge, or other craft for passing through any lock, canal, canalized river, or other work for the use and benefit of navigation, now belonging to the United States or that may be hereafter acquired or constructed...."
6.24	There are adverse effects of increased boating such as bank erosion and water turbidity which must be considered.	See paragraph 6.95 of the final.
6.25	Who would be responsible for the recreational improvements?	In accordance with the Federal Water Project Recreation Act, non-federal interests would be required to bear part of the overall development costs and assume all of the cost for managing the recreation developments.

8.02 Statements relating to fish migration up the Lower Fox River, through the Winnebago Pool, to spawning sites on the Wolf River need to be re-examined. In all likelihood, the stretch from river mile 23 to 33 must have acted as a barrier to fish migration due to the gradient. The presence of Lake Sturgeon in the Winnebago Pool probably reflects migrations from the Wisconsin River, via Glacial Lake Whillelsey, or from the Wisconsin River via the pre-glacial route of the Wolf River. They should not be viewed as remnants from Green Bay or Lake Michigan.

This and other statements relating to the movement of aquatic organisms between navigation pools have been modified in the final (see paragraphs 4.240 and 8.03).

8.09 Through seven sections of this report we are told the project costs about $350,000 per year. Now in the last paragraph of the text, we are told the cost of $1,000,000 annually. This points out the need for a detailed cost breakdown for all aspects of the project.

A detailed cost breakdown for all aspects of the project was presented in Tables 1.7 and 1.8 of the draft statement. These tables, together with the supporting narrative of the text, correctly place the total annual expenditure to operate and maintain the entire Federal project at approximately $1 million (1974 price levels), and the allocated estimated cost of operation and maintenance of the lock system only at about $361,000 per year.

<u>Appendix</u>

C-5 High water stages can cause trouble at any time when floating vegetation mats are involved. High water can float the mats out and cause large losses to the vegetative cover. It is not an indefinite loss, but a very real one which can sometimes be measured in acres at the time of its occurence. Over a period of time, acreage losses become losses in terms of square miles.

The subject remarks have been deleted from the text of the final statement.

G-1 Pintails may not be as rare in this pool as is indicated.

In most cases, a single most characteristic designation was used by Dr. Kaspar (UW-Oshkosh) to categorize individual bird species according to residency status. The difficulty in classifying pintails is evidenced by the S *T (summer resident, rare, transient) designation assigned by Dr. Kaspar to this species.

<u>General Comment</u>

This draft EIS contains much more relevant background data than other statements produced by the Chicago District. Because of the large geographic area affected and varying environmental settings, we feel that refinement of some information is in order as stated previously.

We anticipate that continuing contact between our agencies through the Great Lakes Basin Commission study will enable us to develop a management plan for the river system. In the interim, we advise a course of deferred maintenance dredging where possible. Where dredging must be done, we will need sediment analyses, water quality analyses, engineering plans and the details of proposed spoil disposal sites. We also recommend efforts to reduce water level fluctuations consistent with the legal constraints placed on such operations.

The Chicago District will closely coordinate future project dredging, dredged material disposal, and lake regulation management activities with the Wisconsin DNR.

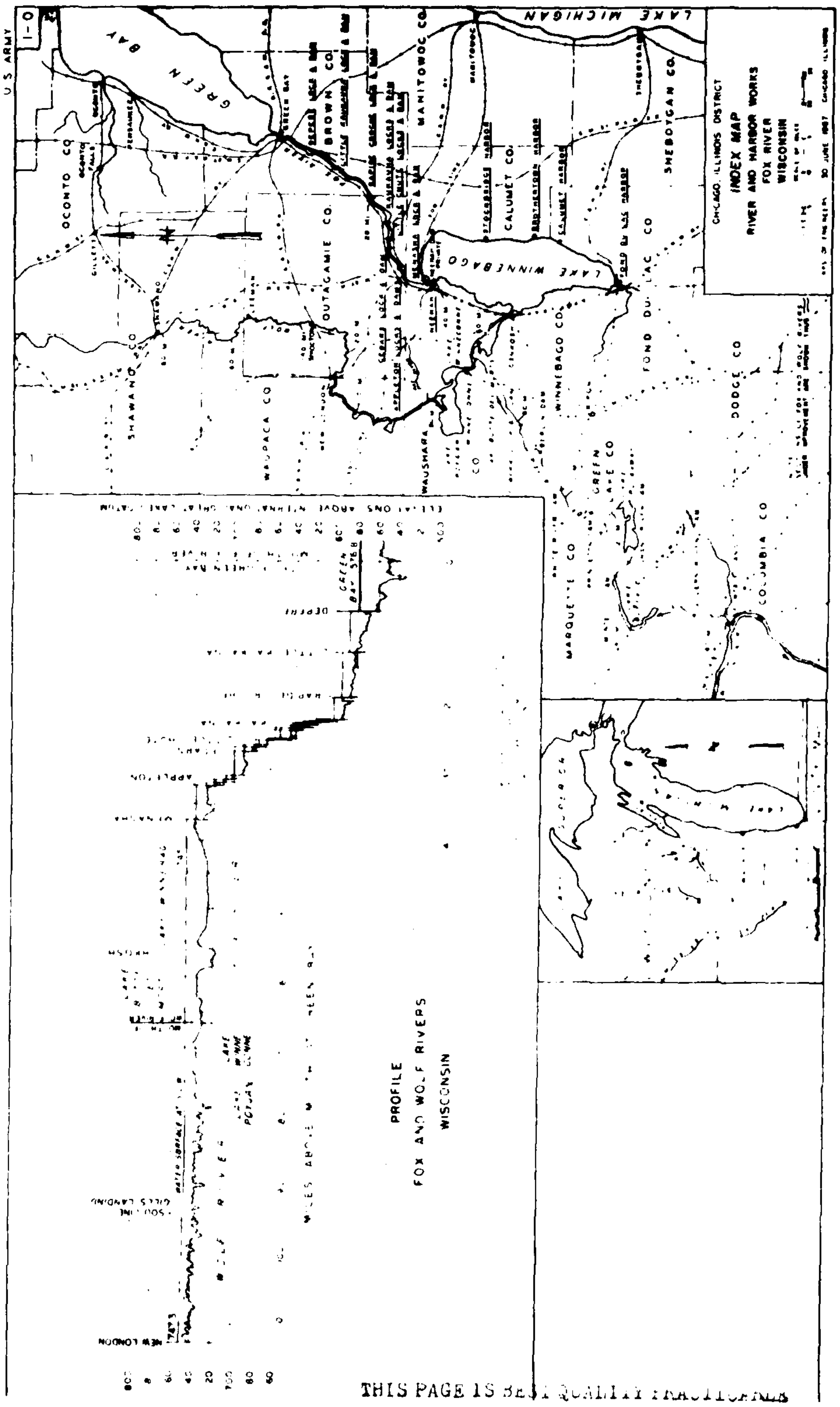
Sincerely,
Bureau of Environmental Impact

C. D. Besadny
Director

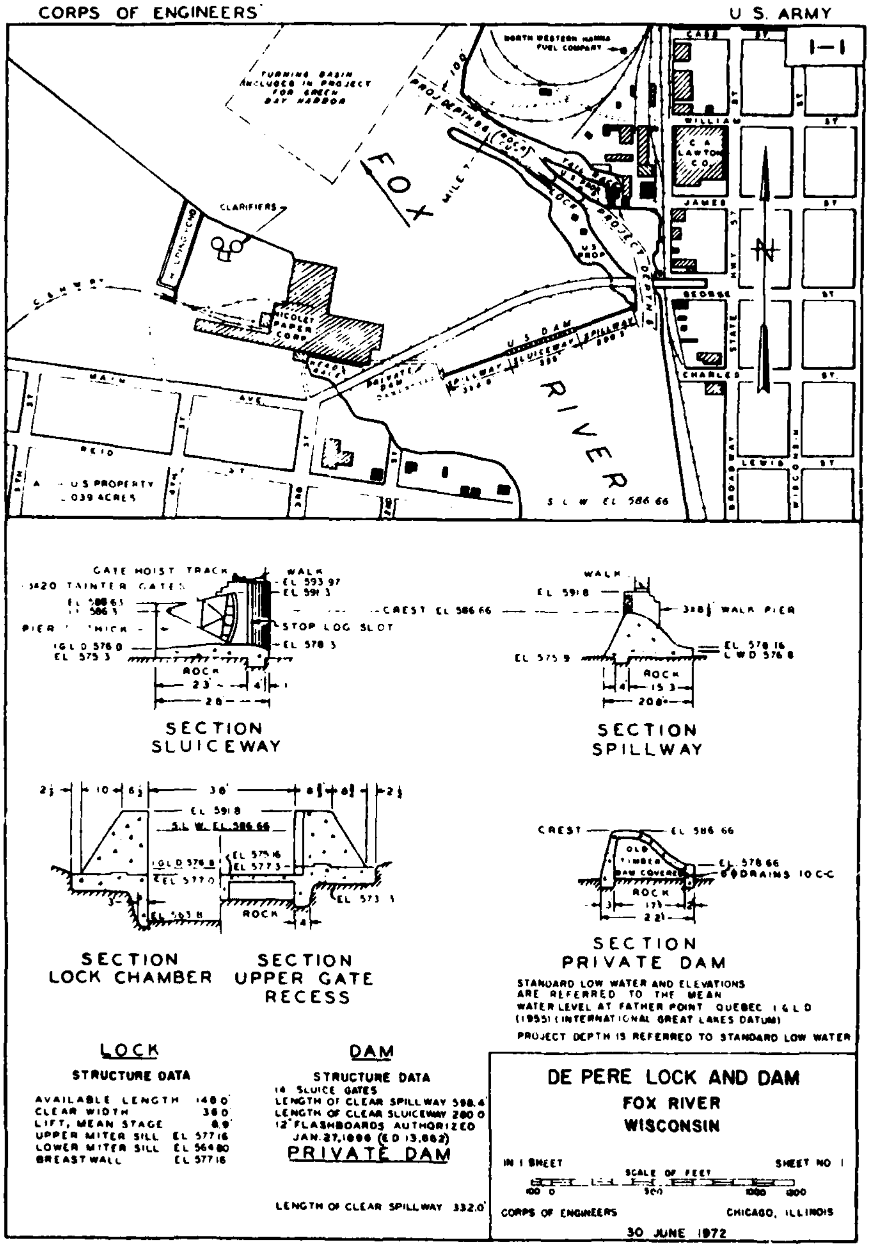
cc: Dick Hoppe

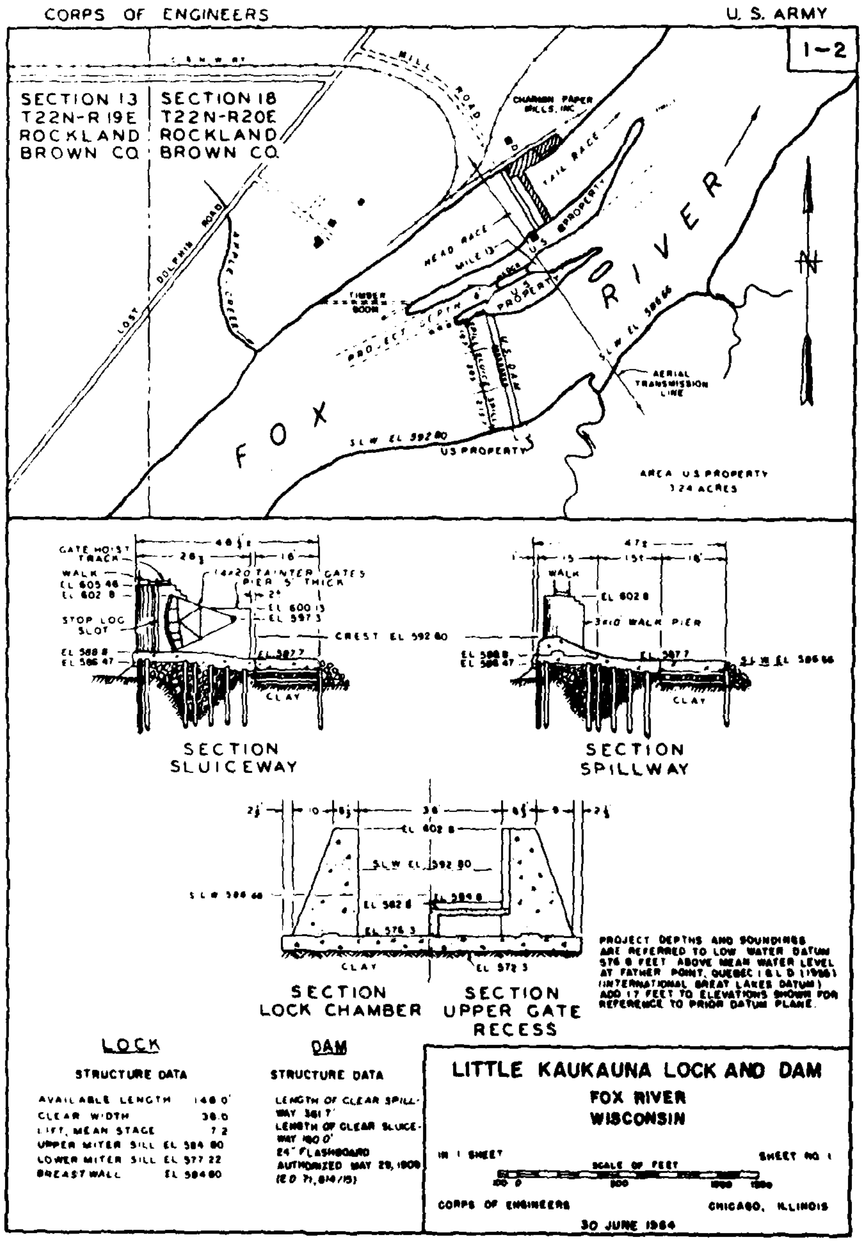
APPENDIX A: FOX RIVER, WISCONSIN PROJECT MAPS

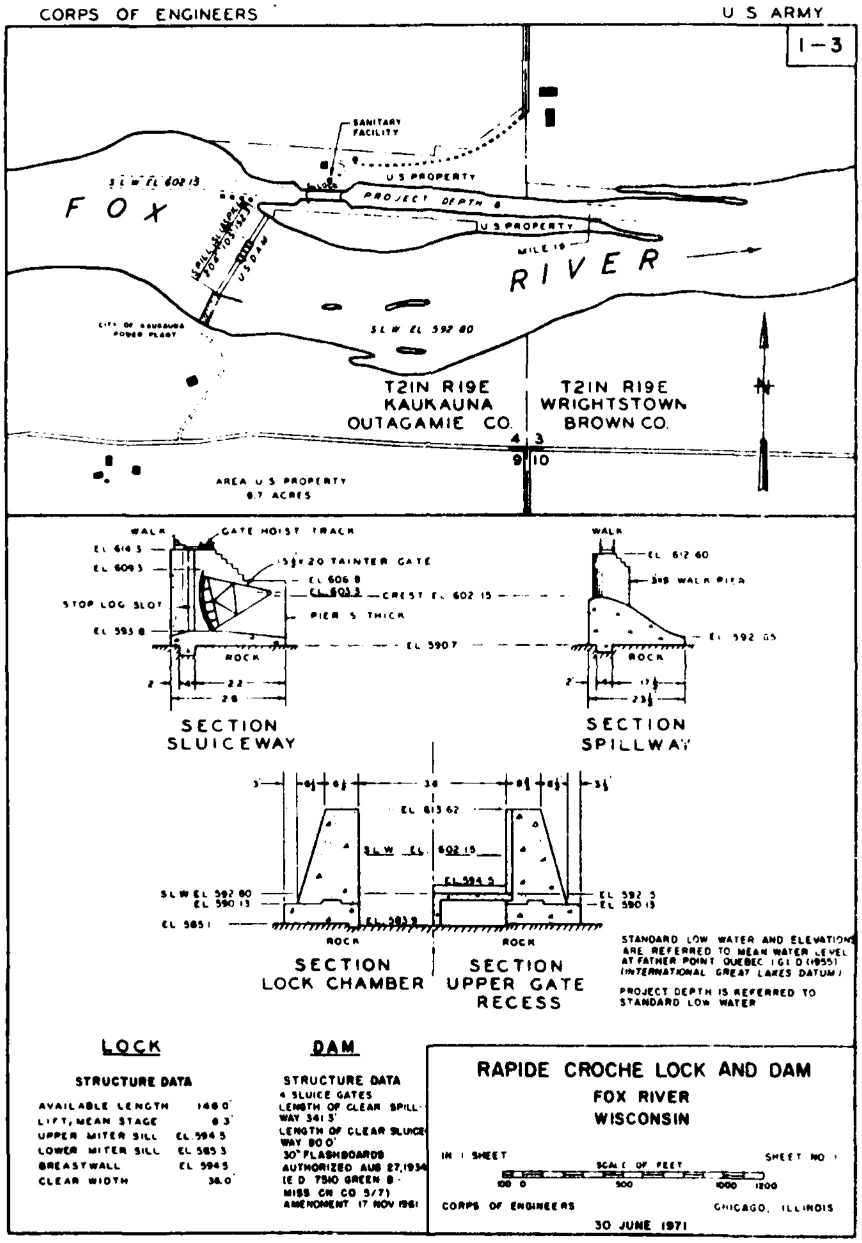
AND NAVIGATION CHARTS



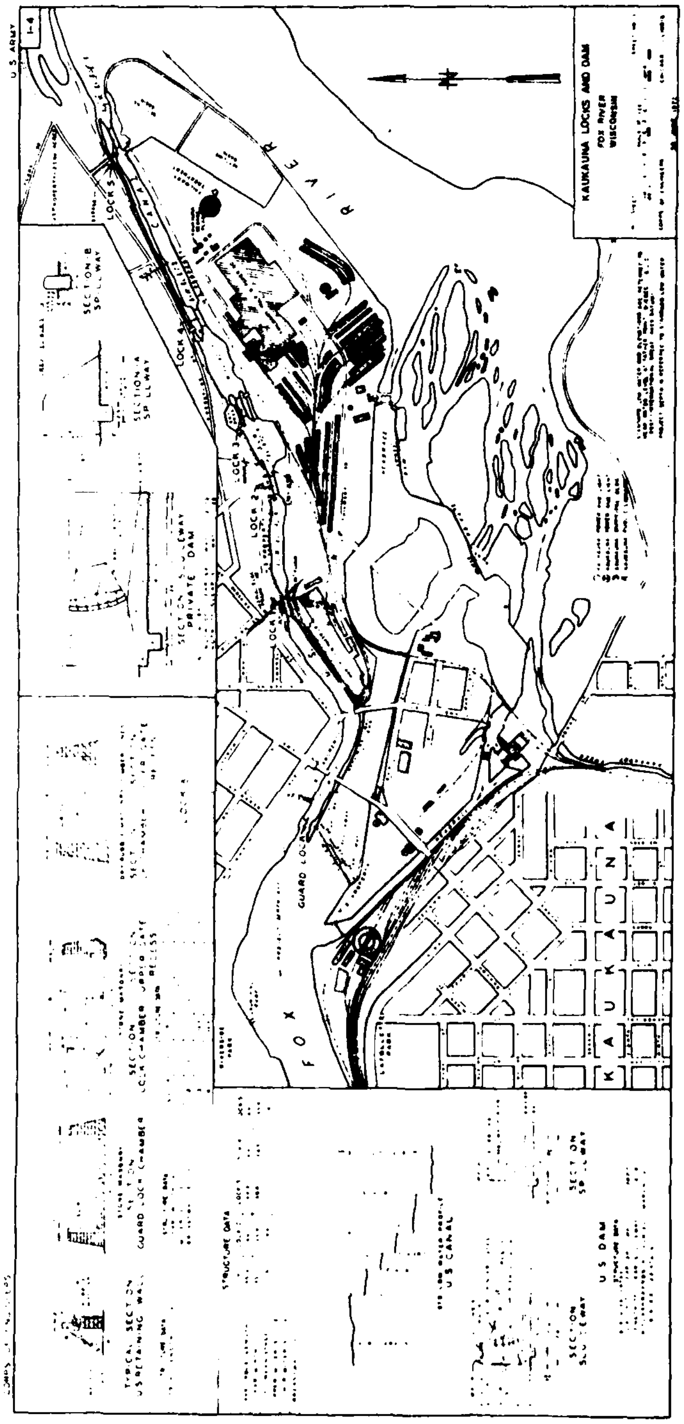
U.S. ARMY
CHICAGO, ILLINOIS DISTRICT
INDEX MAP
RIVER AND HARBOR WORKS
FOX RIVER
WISCONSIN
LAKE MICHIGAN
GREEN BAY
LAKE WINNEBAGO
OCONTO CO
BROWN CO.
MANITOWOC CO.
OUTAGAMIE CO.
CALUMET CO.
SHEBOYGAN CO.
SHAWANO CO
WAUPACA CO
WINNEBAGO CO
FOND DU LAC CO
DODGE CO
GREEN LAKE CO
MARQUETTE CO
COLUMBIA CO
WAUSHARA CO
PROFILE
FOX AND WOLF RIVERS
WISCONSIN
APPLETON
NEW LONDON
DEPERE

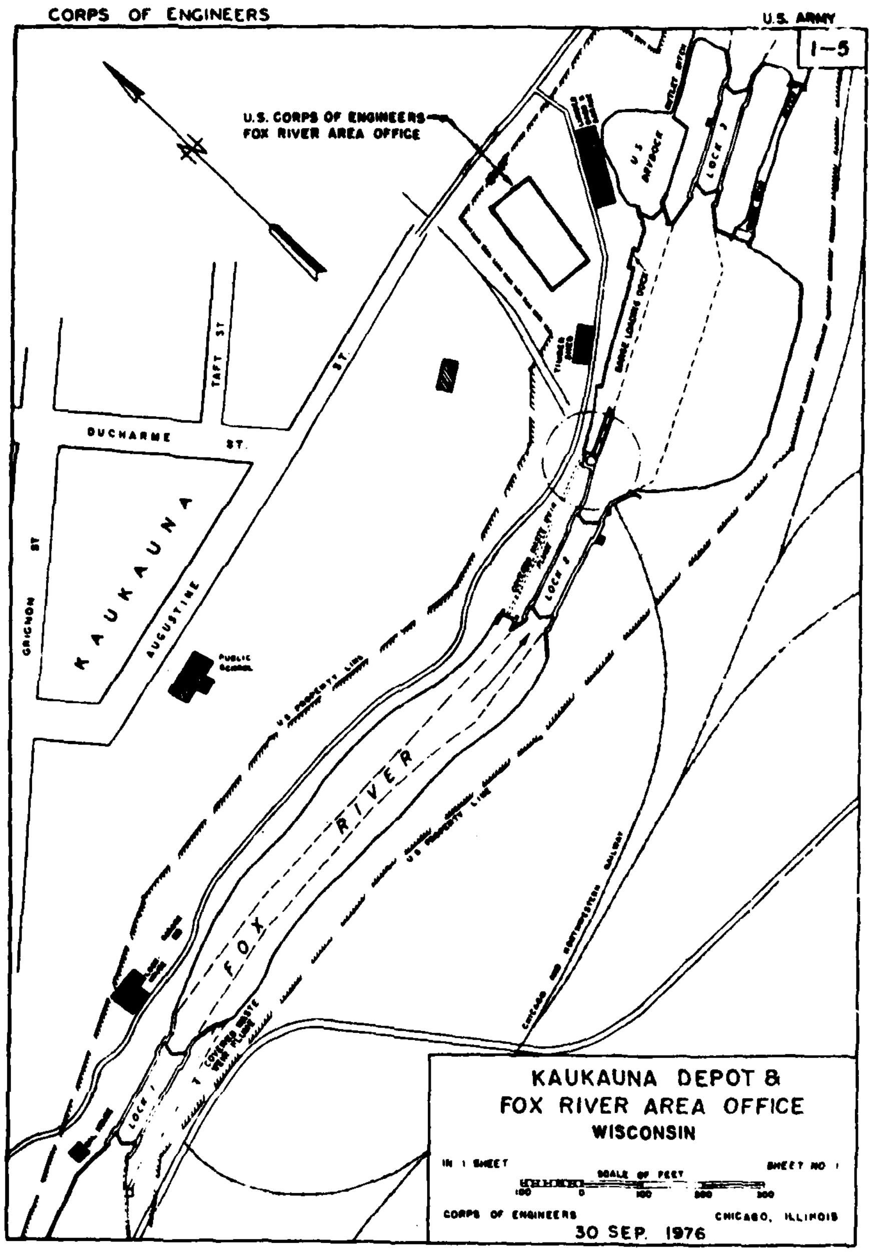

CORPS OF ENGINEERS
U S. ARMY
1—1
FOX
RIVER
CLARIFIERS
NICOLET PAPER CORP
U S DAM
PRIVATE DAM
MAIN AVE
REID
U S PROPERTY
WILLIAM
JAMES
GEORGE
CHARLES
LEWIS
C A LAWTON CO
S L W EL 586 66
SECTION
SLUICEWAY
SECTION
SPILLWAY
SECTION
LOCK CHAMBER
SECTION
UPPER GATE
RECESS
SECTION
PRIVATE DAM
STANDARD LOW WATER AND ELEVATIONS
ARE REFERRED TO THE MEAN
WATER LEVEL AT FATHER POINT QUEBEC I G L D
(1955) (INTERNATIONAL GREAT LAKES DATUM)
PROJECT DEPTH IS REFERRED TO STANDARD LOW WATER
LOCK
STRUCTURE DATA
AVAILABLE LENGTH 148.0'
CLEAR WIDTH 36.0'
LIFT, MEAN STAGE 8.9'
UPPER MITER SILL EL 577.16
LOWER MITER SILL EL 564.80
BREAST WALL EL 577.16
DAM
STRUCTURE DATA
14 SLUICE GATES
LENGTH OF CLEAR SPILLWAY 398.4'
LENGTH OF CLEAR SLUICEWAY 280.0
12" FLASHBOARDS AUTHORIZED
JAN. 27, 1888 (E D 13,862)
PRIVATE DAM
LENGTH OF CLEAR SPILLWAY 332.0'
DE PERE LOCK AND DAM
FOX RIVER
WISCONSIN
IN 1 SHEET
SHEET NO 1
SCALE OF FEET
CORPS OF ENGINEERS
CHICAGO, ILLINOIS
30 JUNE 1972

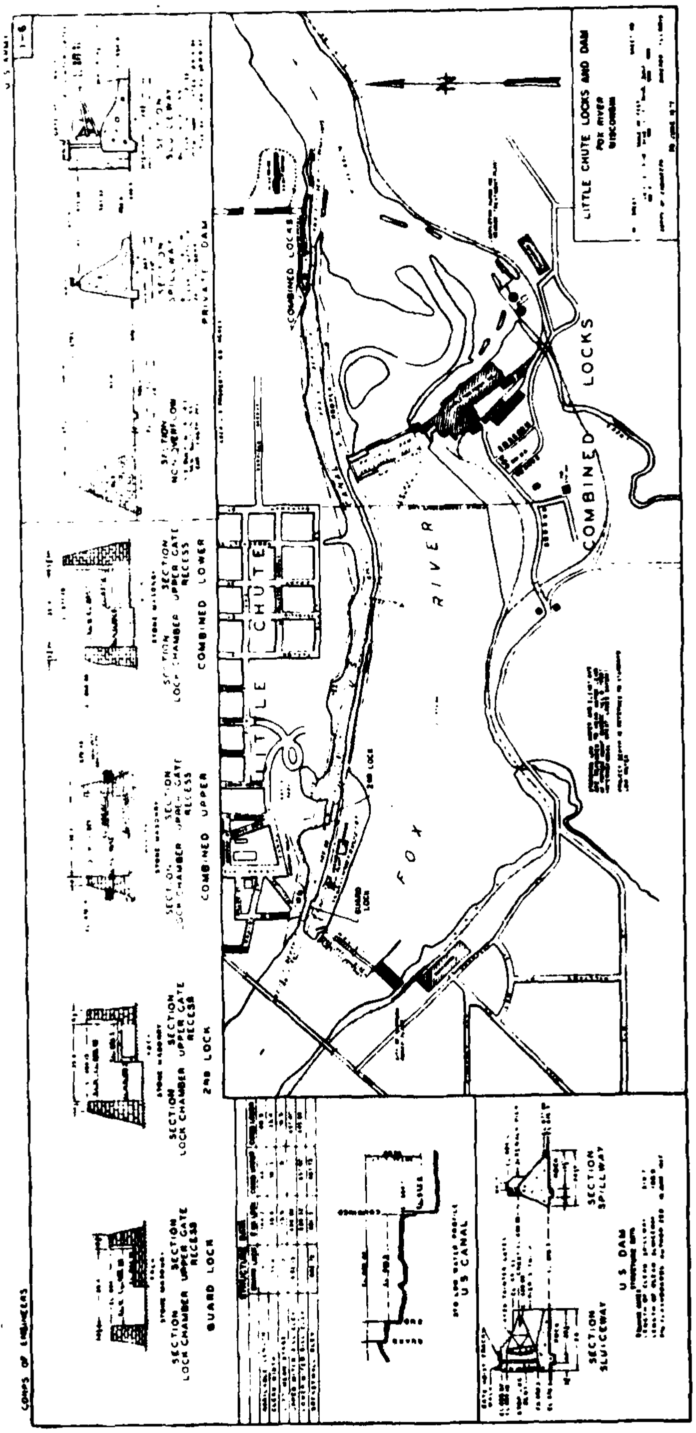

CORPS OF ENGINEERS
U. S. ARMY
1-2
SECTION 13
T22N-R19E
ROCKLAND
BROWN CO.
SECTION 18
T22N-R20E
ROCKLAND
BROWN CO.
FOX RIVER
SECTION
SLUICEWAY
SECTION
SPILLWAY
SECTION
LOCK CHAMBER
SECTION
UPPER GATE
RECESS
PROJECT DEPTHS AND SOUNDINGS ARE REFERRED TO LOW WATER DATUM 576.8 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC I.G.L.D. (1955) (INTERNATIONAL GREAT LAKES DATUM) ADD 17 FEET TO ELEVATIONS SHOWN FOR REFERENCE TO PRIOR DATUM PLANE.
LOCK
STRUCTURE DATA
AVAILABLE LENGTH 146.0'
CLEAR WIDTH 38.0
LIFT, MEAN STAGE 7.2
UPPER MITER SILL EL 584.80
LOWER MITER SILL EL 577.22
BREAST WALL EL 584.80
DAM
STRUCTURE DATA
LENGTH OF CLEAR SPILLWAY 361.7'
LENGTH OF CLEAR SLUICEWAY 160.0'
24" FLASHBOARD
AUTHORIZED MAY 29, 1909
(E.D. 71,814/15)
LITTLE KAUKAUNA LOCK AND DAM
FOX RIVER
WISCONSIN
IN 1 SHEET
SHEET NO. 1
SCALE OF FEET
CORPS OF ENGINEERS
CHICAGO, ILLINOIS
30 JUNE 1964


CORPS OF ENGINEERS
U S ARMY
1-3
SANITARY FACILITY
U S PROPERTY
PROJECT DEPTH 6
U S PROPERTY
MILE 19
FOX
RIVER
S L W EL 592 80
CITY OF KAUKAUNA POWER PLANT
T21N R19E
KAUKAUNA
OUTAGAMIE CO.
T21N R19E
WRIGHTSTOWN
BROWN CO.
AREA U S PROPERTY
9.7 ACRES
N
WALK
GATE HOIST TRACK
STOP LOG SLOT
CREST EL 602 15
PIER 5 THICK
EL 590.7
ROCK
SECTION
SLUICEWAY
SECTION
SPILLWAY
EL 613 62
SLW EL 602 15
ROCK
SECTION
LOCK CHAMBER
SECTION
UPPER GATE
RECESS
STANDARD LOW WATER AND ELEVATIONS ARE REFERRED TO MEAN WATER LEVEL AT FATHER POINT QUEBEC I G L D (1955) (INTERNATIONAL GREAT LAKES DATUM)
PROJECT DEPTH IS REFERRED TO STANDARD LOW WATER
LOCK
STRUCTURE DATA
AVAILABLE LENGTH 146.0'
LIFT, MEAN STAGE 8.3'
UPPER MITER SILL EL 594.5
LOWER MITER SILL EL 585.3
BREASTWALL EL 594.5
CLEAR WIDTH 36.0'
DAM
STRUCTURE DATA
4 SLUICE GATES
LENGTH OF CLEAR SPILLWAY 341.3'
LENGTH OF CLEAR SLUICEWAY 80.0'
30" FLASHBOARDS
AUTHORIZED AUG 27,1934
(E D 7510 GREEN B - MISS CN CO 5/7)
AMENDMENT 17 NOV 1961
RAPIDE CROCHE LOCK AND DAM
FOX RIVER
WISCONSIN
IN 1 SHEET
SHEET NO 1
SCALE OF FEET
CORPS OF ENGINEERS
CHICAGO, ILLINOIS
30 JUNE 1971

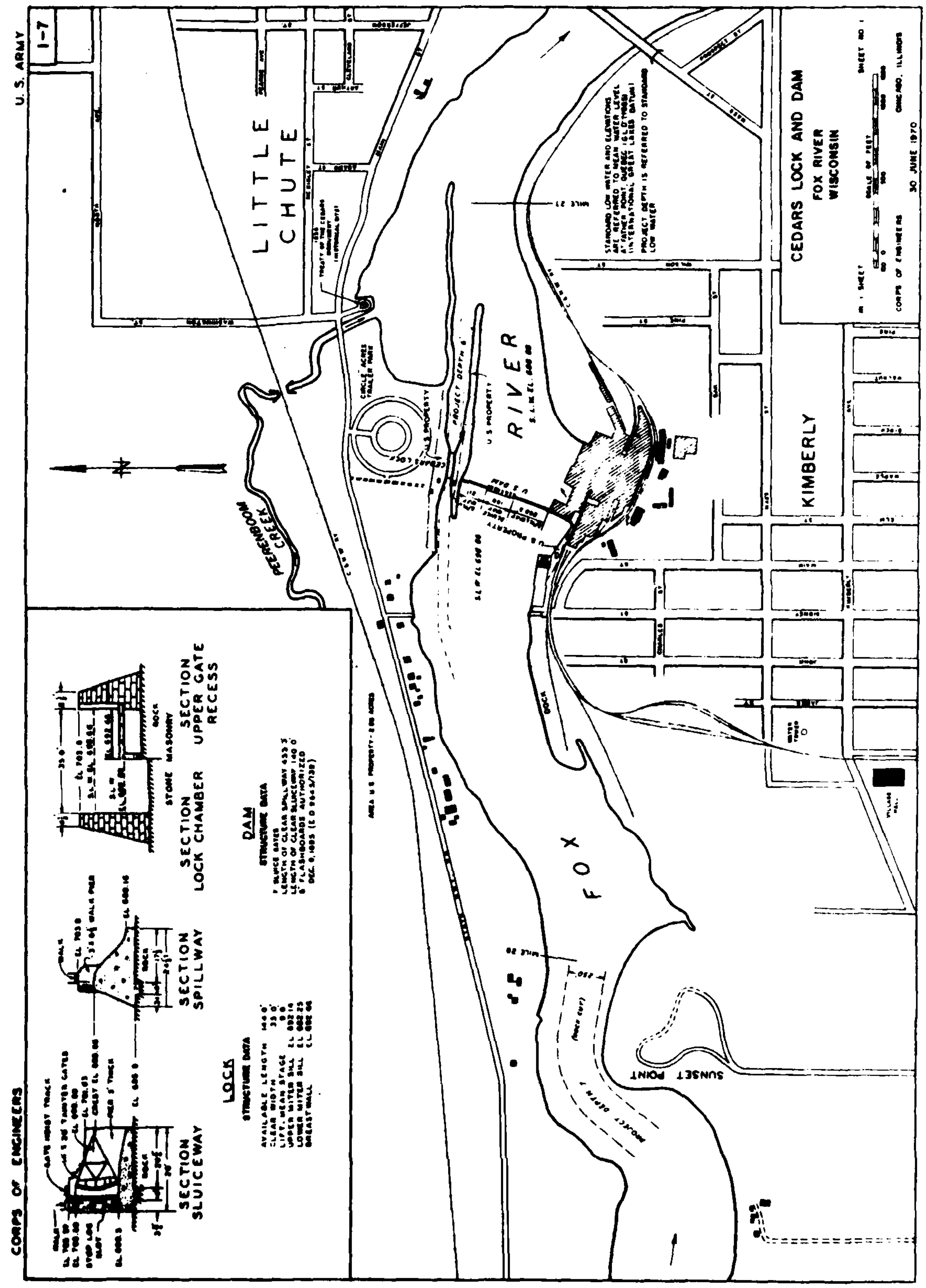
A-6


KAUKAUNA LOCKS AND DAM
FOX RIVER
WISCONSIN
FOX
RIVER
KAUKAUNA
GUARD LOCK
LOCK 3
LOCK 2
LOCKS
CANAL
US CANAL
US DAM
PRIVATE DAM
SECTION A SPILLWAY
SECTION B SPILLWAY
STRUCTURE DATA
U S ARMY

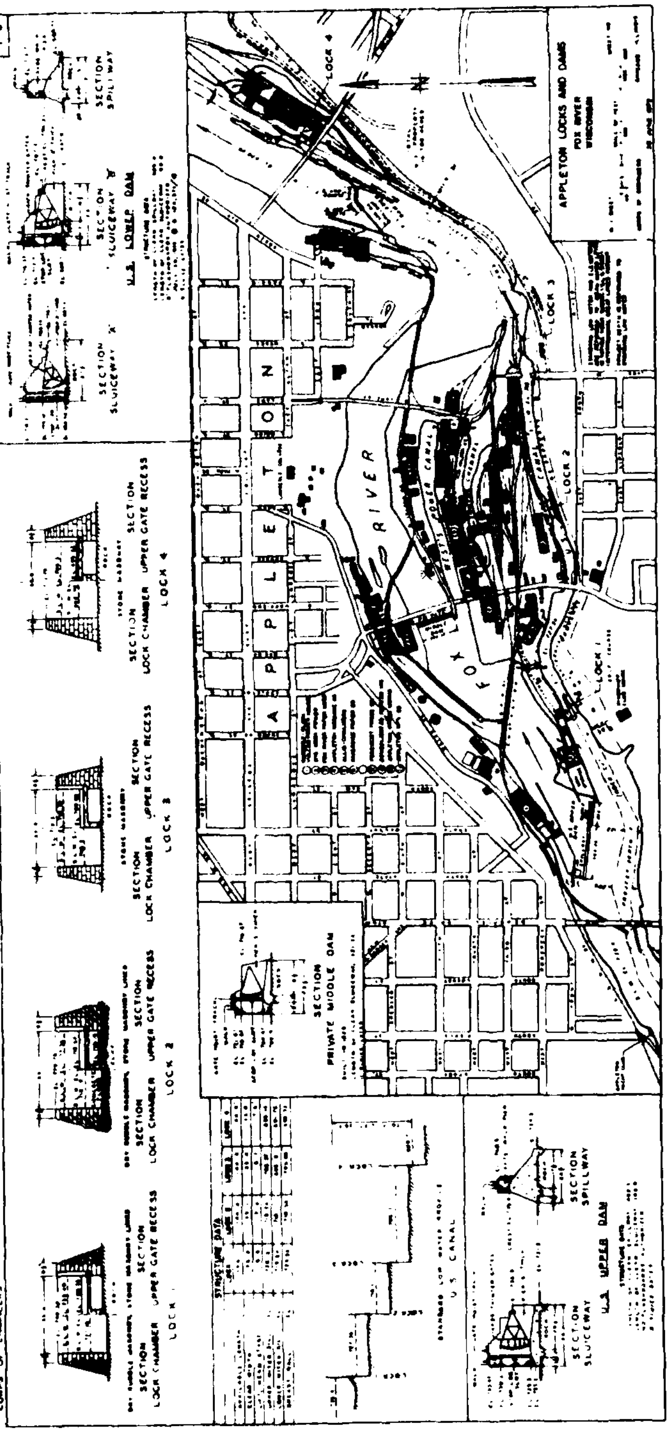

CORPS OF ENGINEERS
U.S. ARMY
I-5
U.S. CORPS OF ENGINEERS
FOX RIVER AREA OFFICE
TAFT ST
ST.
DUCHARME ST.
GRIGNON ST
KAUKAUNA
AUGUSTINE
PUBLIC SCHOOL
U.S. PROPERTY LINE
FOX RIVER
LOCK 1
LOCK 2
LOCK 3
U.S. DRYDOCK
CHICAGO AND NORTHWESTERN RAILWAY
KAUKAUNA DEPOT &
FOX RIVER AREA OFFICE
WISCONSIN
IN 1 SHEET
SHEET NO 1
SCALE OF FEET
CORPS OF ENGINEERS
CHICAGO, ILLINOIS
30 SEP. 1976

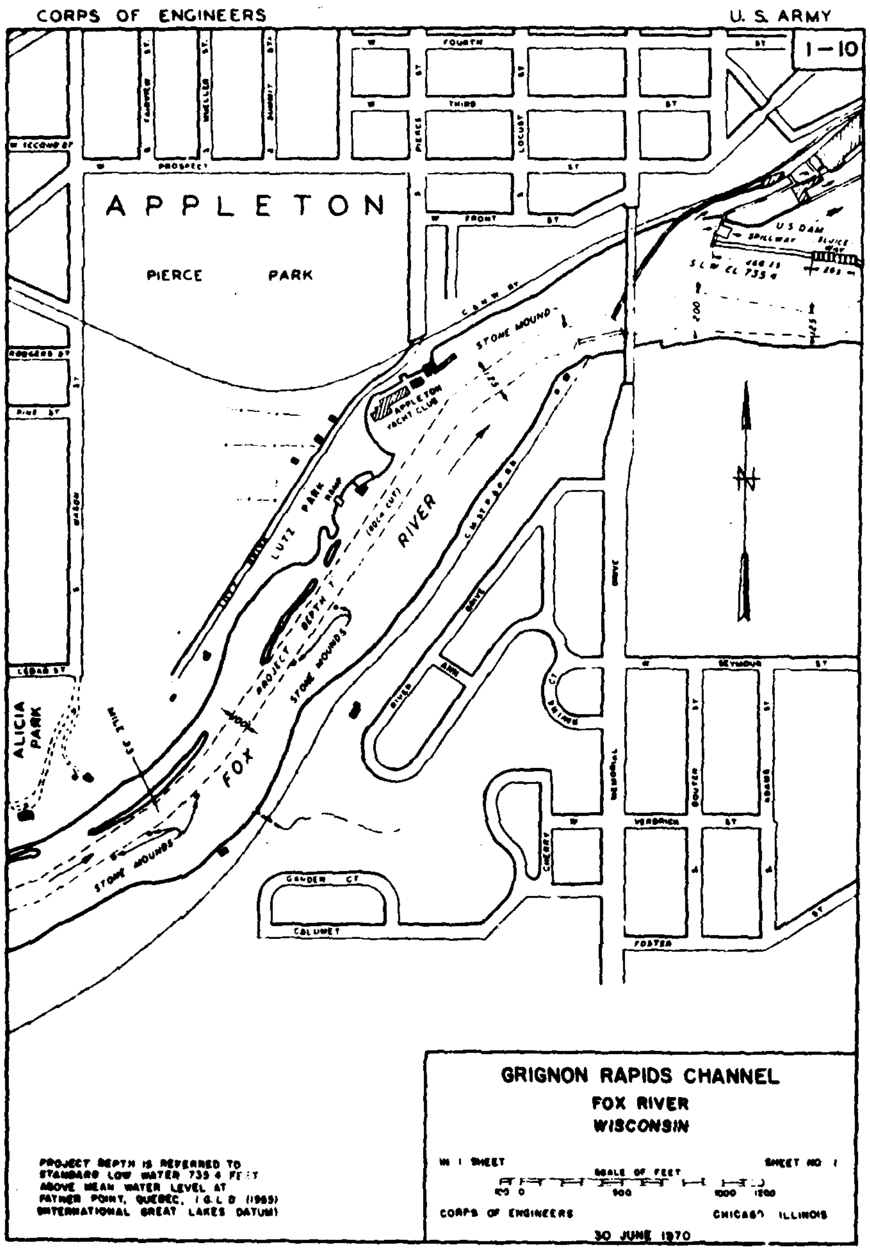


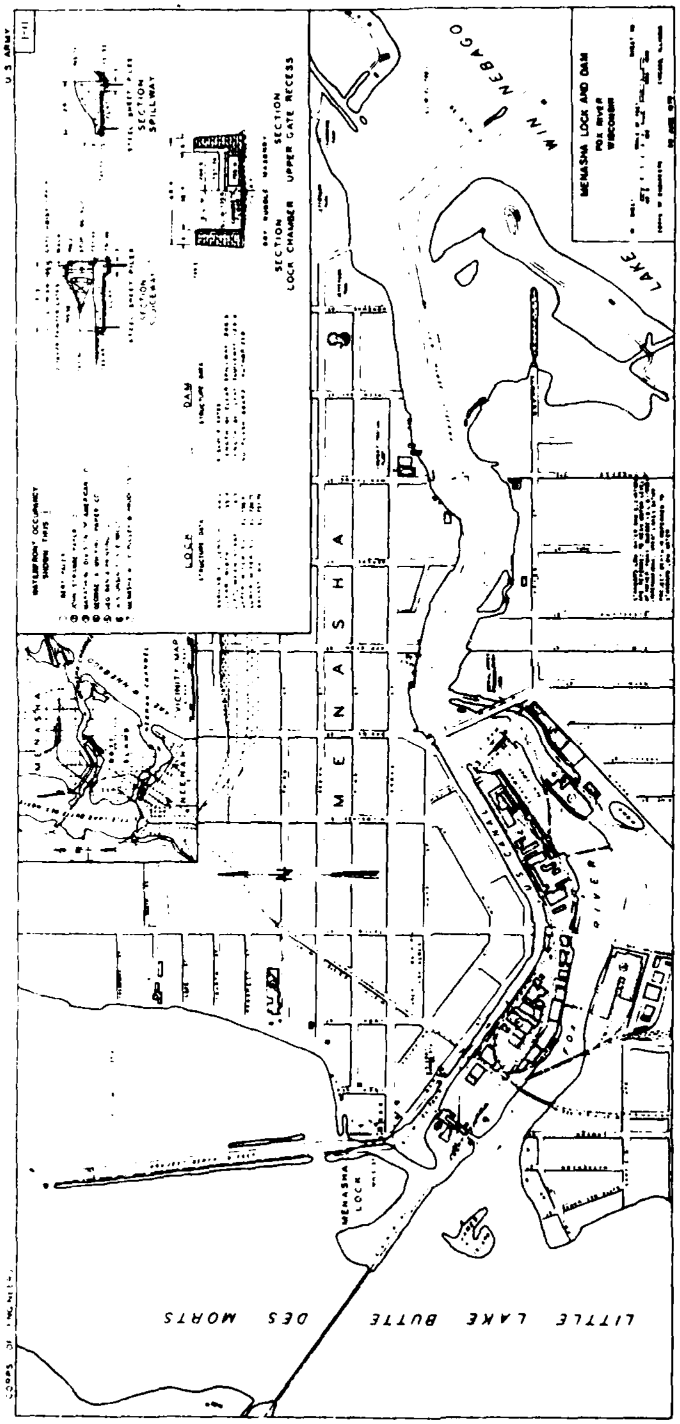
LITTLE CHUTE LOCKS AND DAM
FOX RIVER
WISCONSIN
COMBINED LOCKS
LITTLE CHUTE
F O X
R I V E R
SECTION NON-OVERFLOW
PRIVATE DAM
SECTION LOCK CHAMBER
SECTION UPPER GATE RECESS
COMBINED LOWER
COMBINED UPPER
2ND LOCK
GUARD LOCK
U S CANAL
U S DAM
SECTION SLUICEWAY
SECTION SPILLWAY
CORPS OF ENGINEERS


U. S. ARMY
CORPS OF ENGINEERS
CEDARS LOCK AND DAM
FOX RIVER
WISCONSIN
30 JUNE 1970
LITTLE CHUTE
KIMBERLY
FOX
RIVER
SUNSET POINT
CREEK
SECTION SLUICEWAY
SECTION SPILLWAY
SECTION LOCK CHAMBER
SECTION UPPER GATE RECESS
LOCK
DAM
STRUCTURE DATA

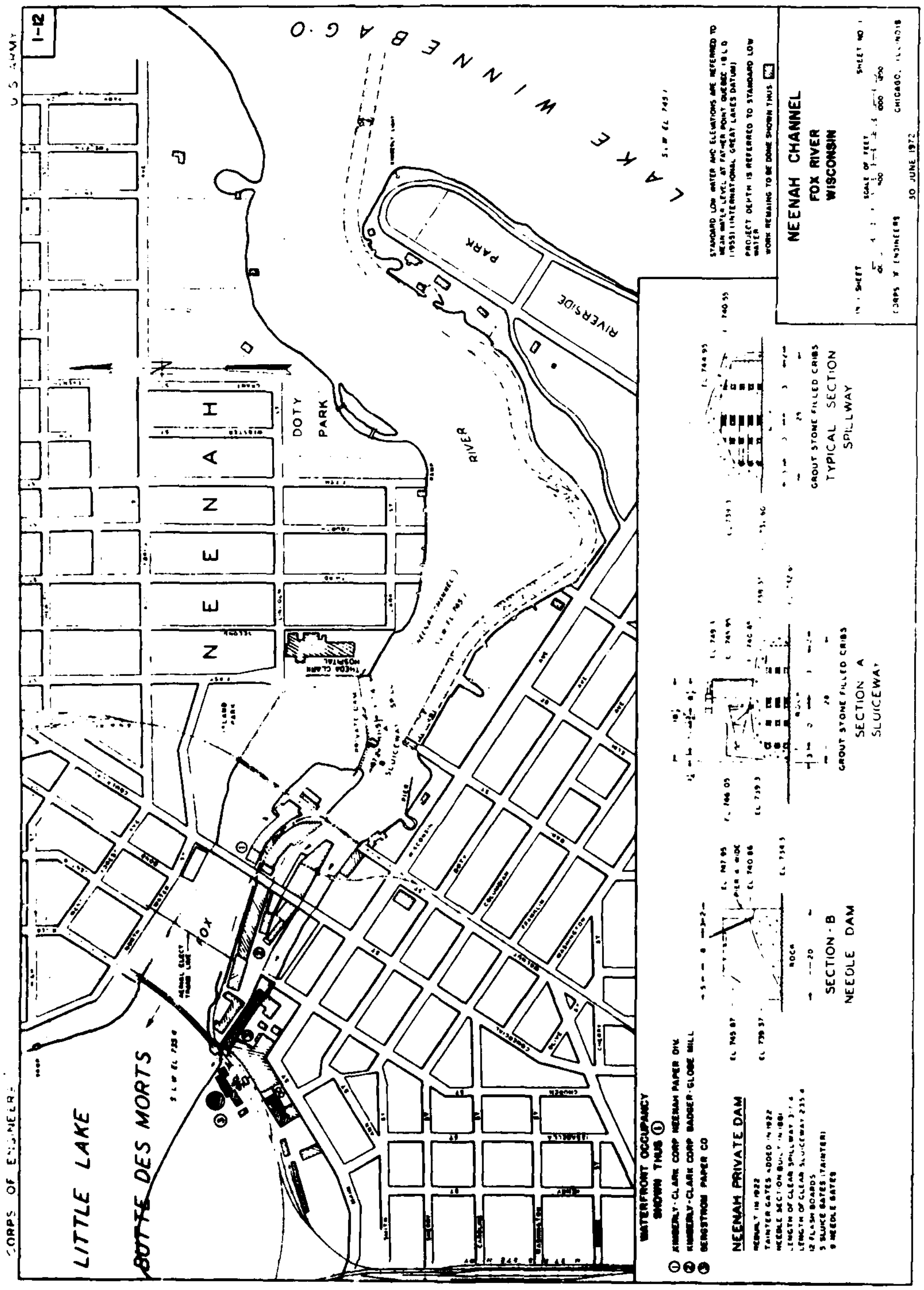
A-10


CORPS OF ENGINEERS
U.S. ARMY
APPLETON LOCKS AND DAMS
FOX RIVER
WISCONSIN
APPLETON
FOX
RIVER
LOCK 1
LOCK 2
LOCK 3
LOCK 4
SECTION
LOCK CHAMBER
SECTION
UPPER GATE RECESS
SECTION
SLUICEWAY 'A'
SECTION
SLUICEWAY 'B'
U.S. LOWER DAM
SECTION
SPILLWAY
SECTION
PRIVATE MIDDLE DAM
U.S. UPPER DAM
STRUCTURE DATA
U.S. CANAL


CORPS OF ENGINEERS
U. S. ARMY
1-10
APPLETON
PIERCE PARK
ALICIA PARK
LUTZ PARK
APPLETON YACHT CLUB
FOX RIVER
STONE MOUND
STONE MOUNDS
PROJECT DEPTH
U S DAM
SPILLWAY
GRIGNON RAPIDS CHANNEL
FOX RIVER
WISCONSIN
IN 1 SHEET
SHEET NO 1
SCALE OF FEET
CORPS OF ENGINEERS
CHICAGO ILLINOIS
30 JUNE 1970
PROJECT DEPTH IS REFERRED TO STANDARD LOW WATER 735 4 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC, I G L D (1955) (INTERNATIONAL GREAT LAKES DATUM)

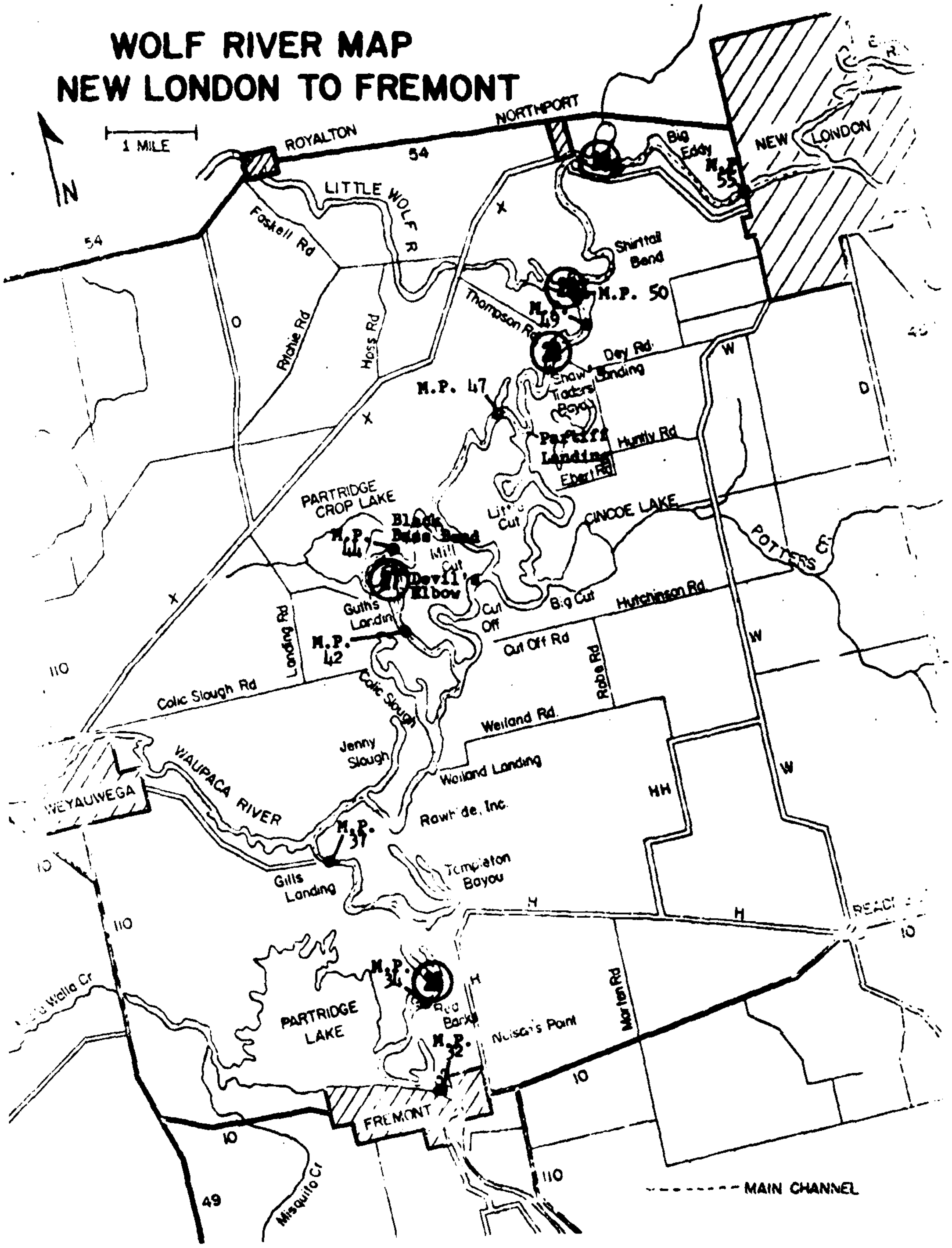

MENASHA LOCK AND DAM
FOX RIVER
WISCONSIN
LAKE WINNEBAGO
MENASHA
MENASHA LOCK
VICINITY MAP
LITTLE LAKE BUTTE DES MORTS
U.S. ARMY
CORPS OF ENGINEERS

A-13



I-12
CORPS OF ENGINEERS
U.S. ARMY
LAKE WINNEBAGO
LITTLE LAKE BUTTE DES MORTS
NEENAH
DOTY PARK
RIVERSIDE PARK
RIVER
FOX
SLUICEWAY
NEENAH CHANNEL
FOX RIVER
WISCONSIN
30 JUNE 1972
NEENAH PRIVATE DAM
WATERFRONT OCCUPANCY SHOWN THUS
SECTION B
NEEDLE DAM
SECTION A
SLUICEWAY
TYPICAL SECTION
SPILLWAY
GROUT STONE FILLED CRIBS

WOLF RIVER MAP
NEW LONDON TO FREMONT



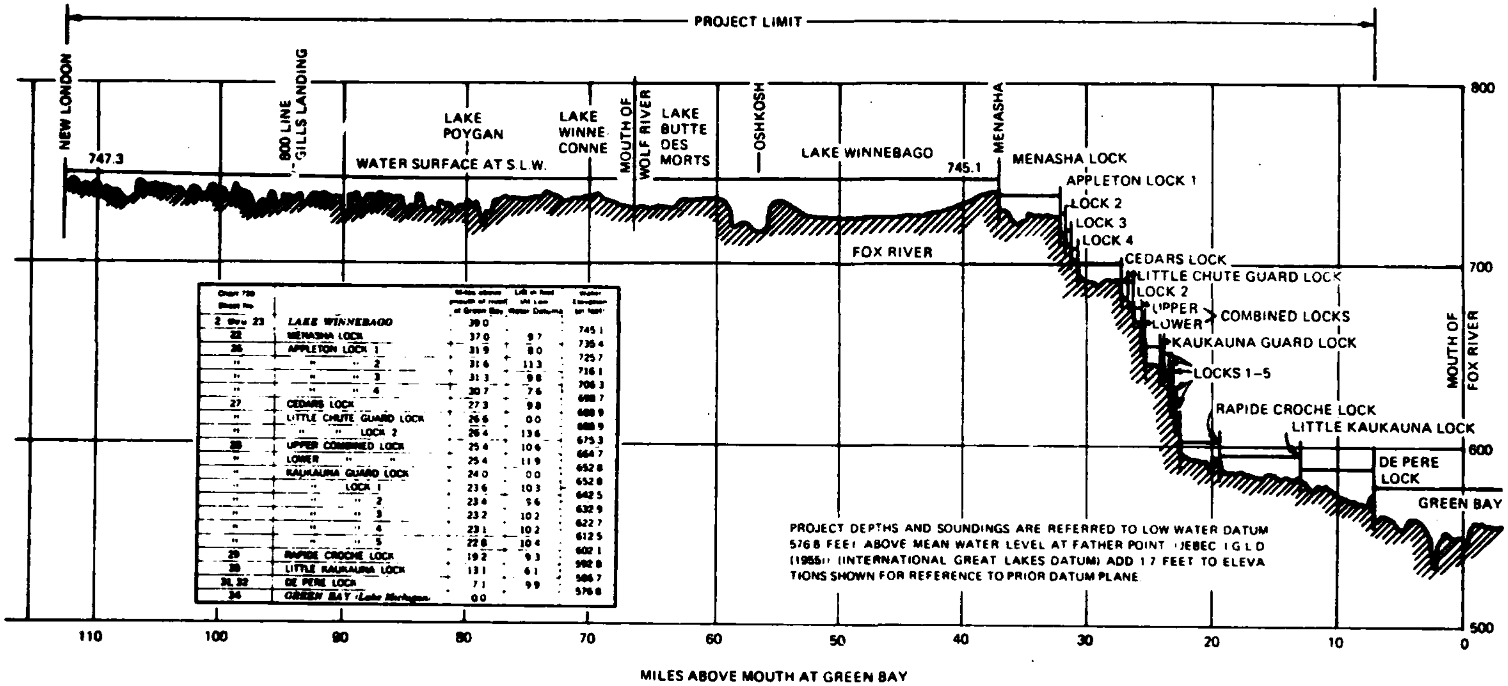
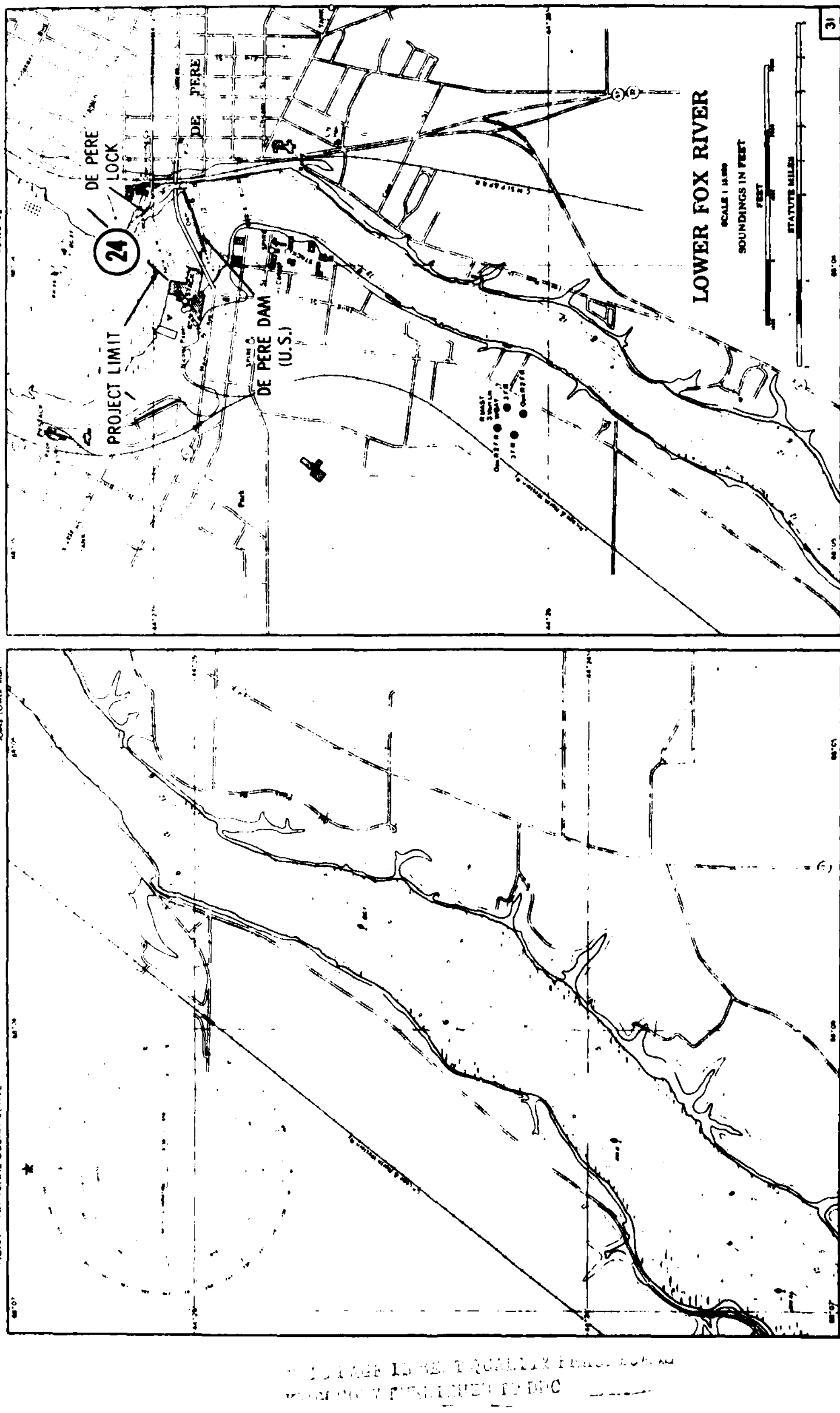
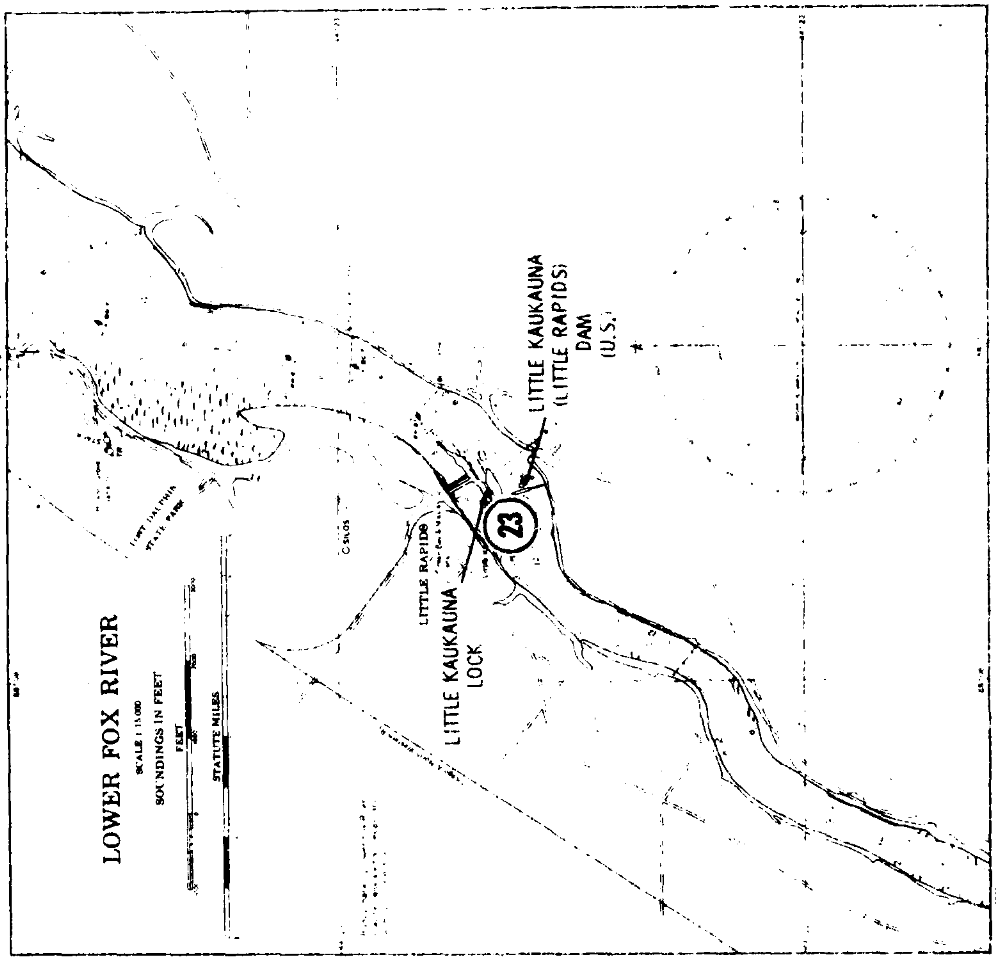
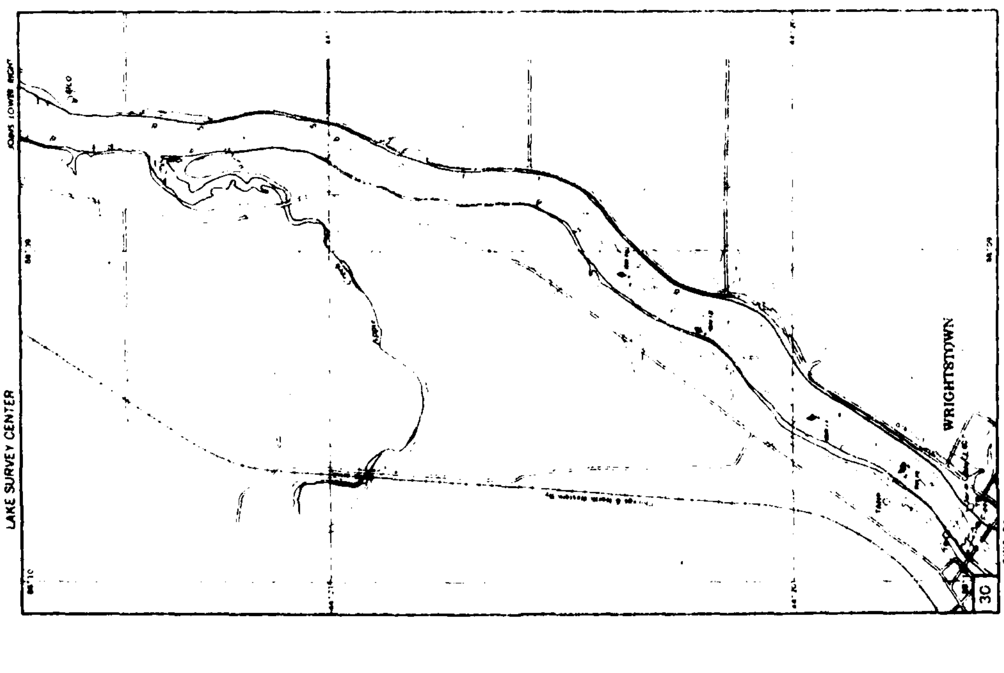
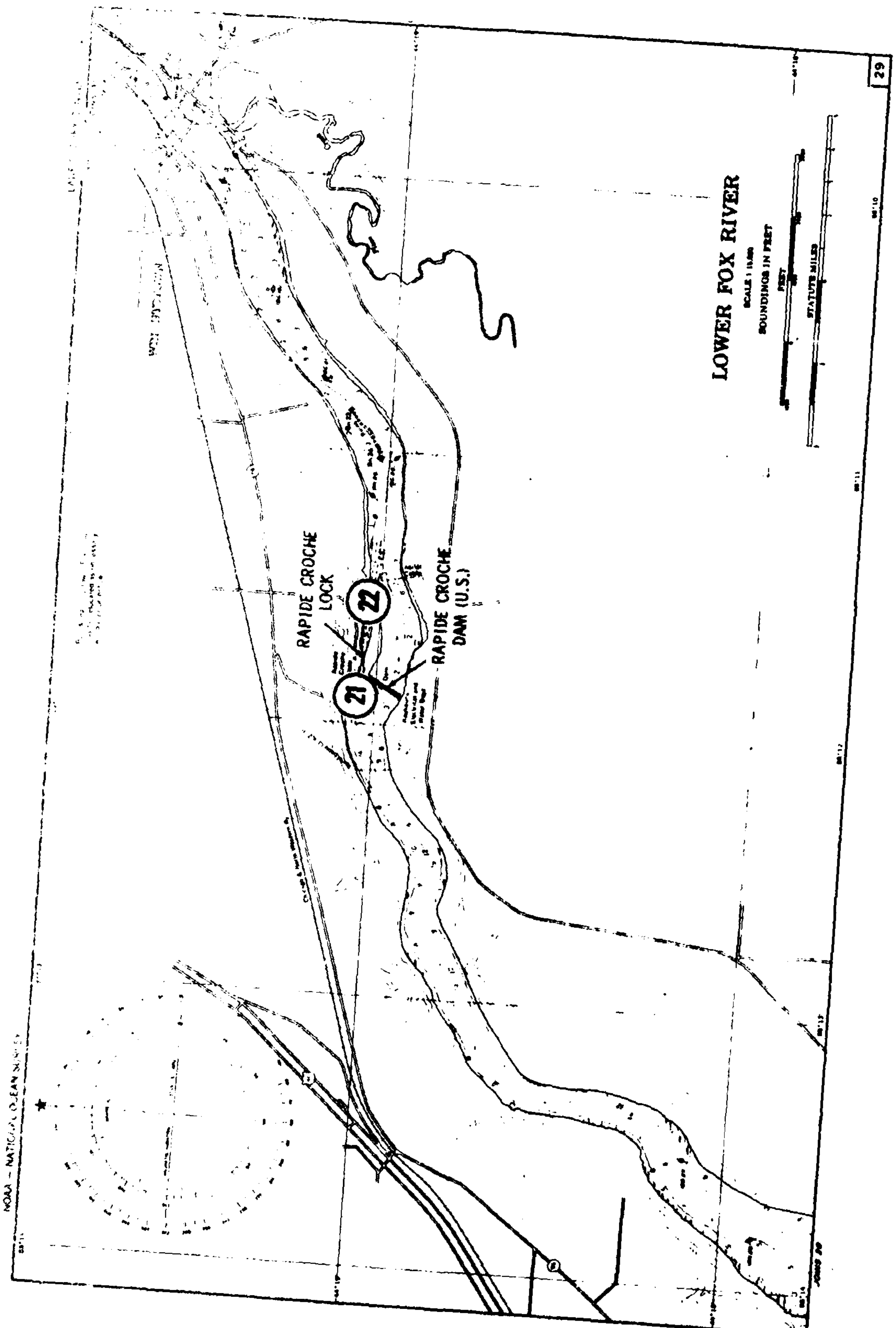


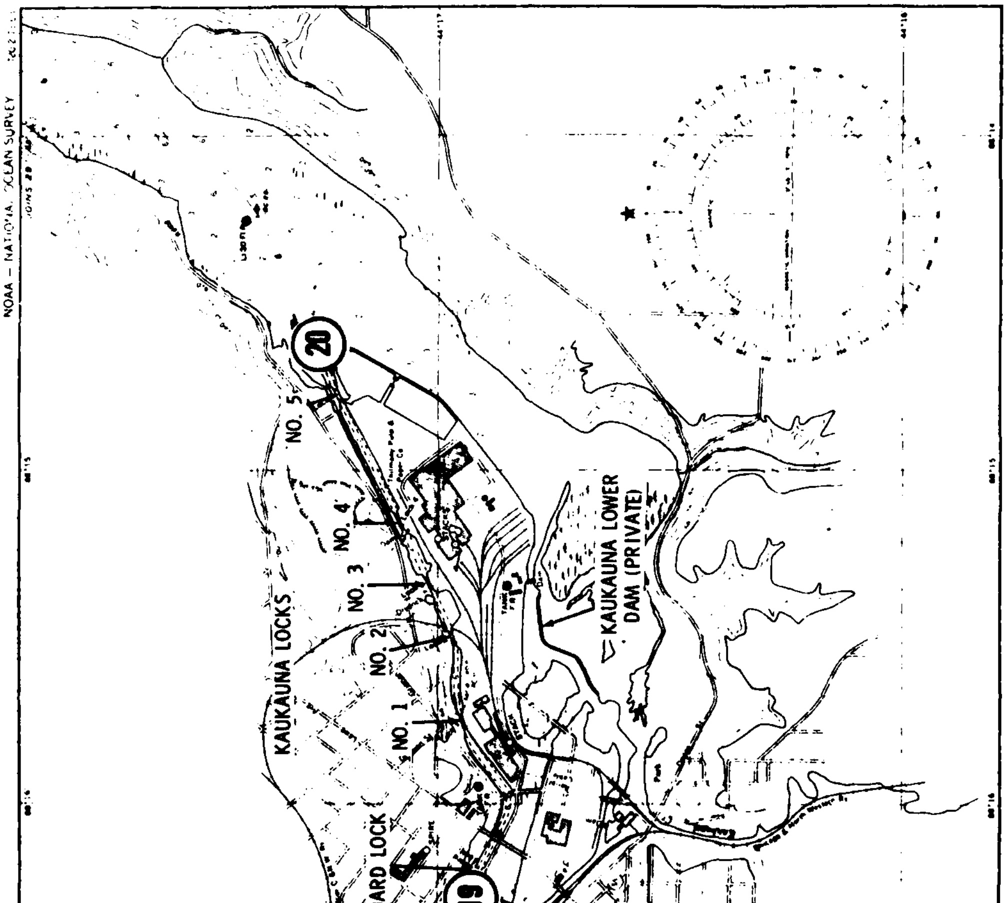
Chart 720 Sheet No.		Miles above mouth of river at Green Bay	Lift in feet at Low Water Datum	Water Elevation (in feet)
2 thru 23	LAKE WINNEBAGO	39.0		745.1
22	MENASHA LOCK	37.0	9.7	735.4
26	APPLETON LOCK 1	31.9	8.0	725.7
"	" " 2	31.6	11.3	716.1
"	" " 3	31.3	9.8	706.3
"	" " 4	30.7	7.6	698.7
27	CEDARS LOCK	27.3	9.8	688.9
"	LITTLE CHUTE GUARD LOCK	26.6	0.0	688.9
"	" " LOCK 2	26.4	13.6	675.3
28	UPPER COMBINED LOCK	25.4	10.6	664.7
"	LOWER " "	25.4	11.9	652.8
"	KAUKAUNA GUARD LOCK	24.0	0.0	652.8
"	" LOCK 1	23.6	10.3	642.5
"	" " 2	23.4	9.6	632.9
"	" " 3	23.2	10.2	622.7
"	" " 4	23.1	10.2	612.5
"	" " 5	22.8	10.4	602.1
29	RAPIDE CROCHE LOCK	19.2	9.3	592.8
30	LITTLE KAUKAUNA LOCK	13.1	6.1	586.7
31, 32	DE PERE LOCK	7.1	9.9	576.8
34	GREEN BAY (Lake Michigan)	0.0		

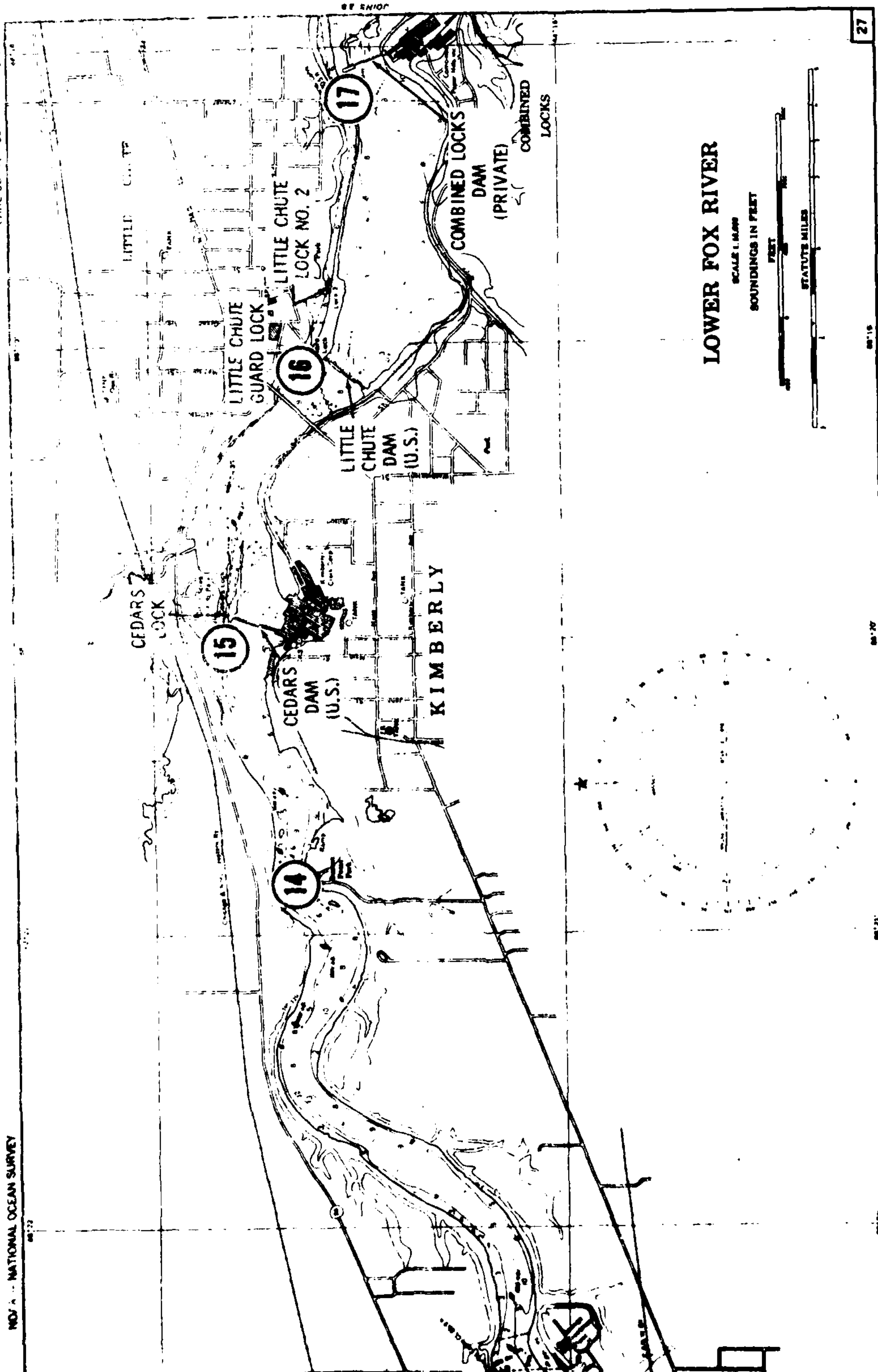

LOWER FOX RIVER
SOUNDINGS IN FEET
STATUTE MILES
DE PERE
LOCK
24
PROJECT LIMIT
DE PERE DAM
(U.S.)
DE PERE
JOINS 32 LAKE SURVEY CENTER
NOAA – NATIONAL OCEAN SURVEY
31

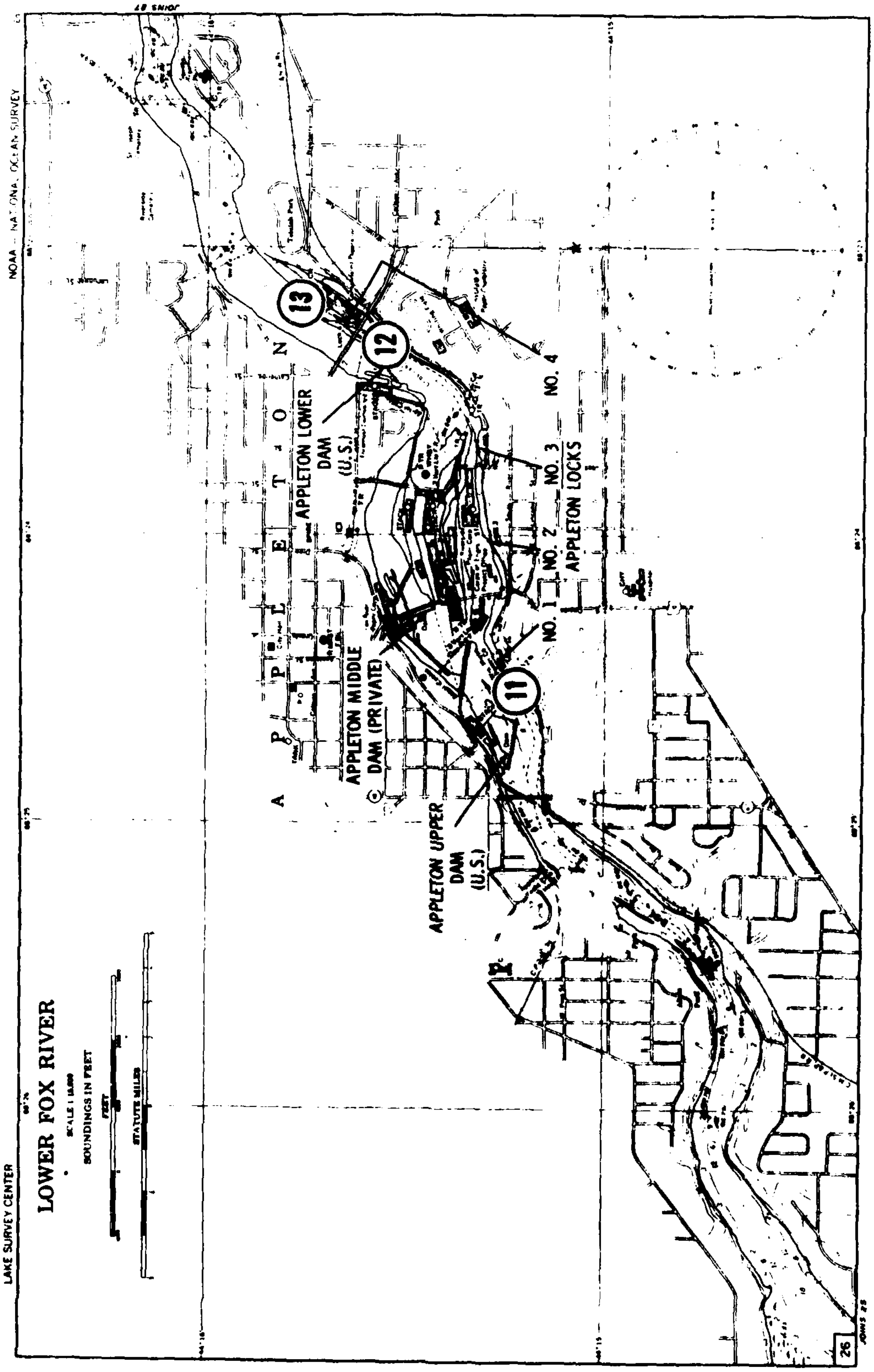

LOWER FOX RIVER
SOUNDINGS IN FEET
FEET
STATUTE MILES
LITTLE KAUKAUNA
LOCK
LITTLE RAPIDS
LITTLE KAUKAUNA
(LITTLE RAPIDS)
DAM
(U.S.)
23

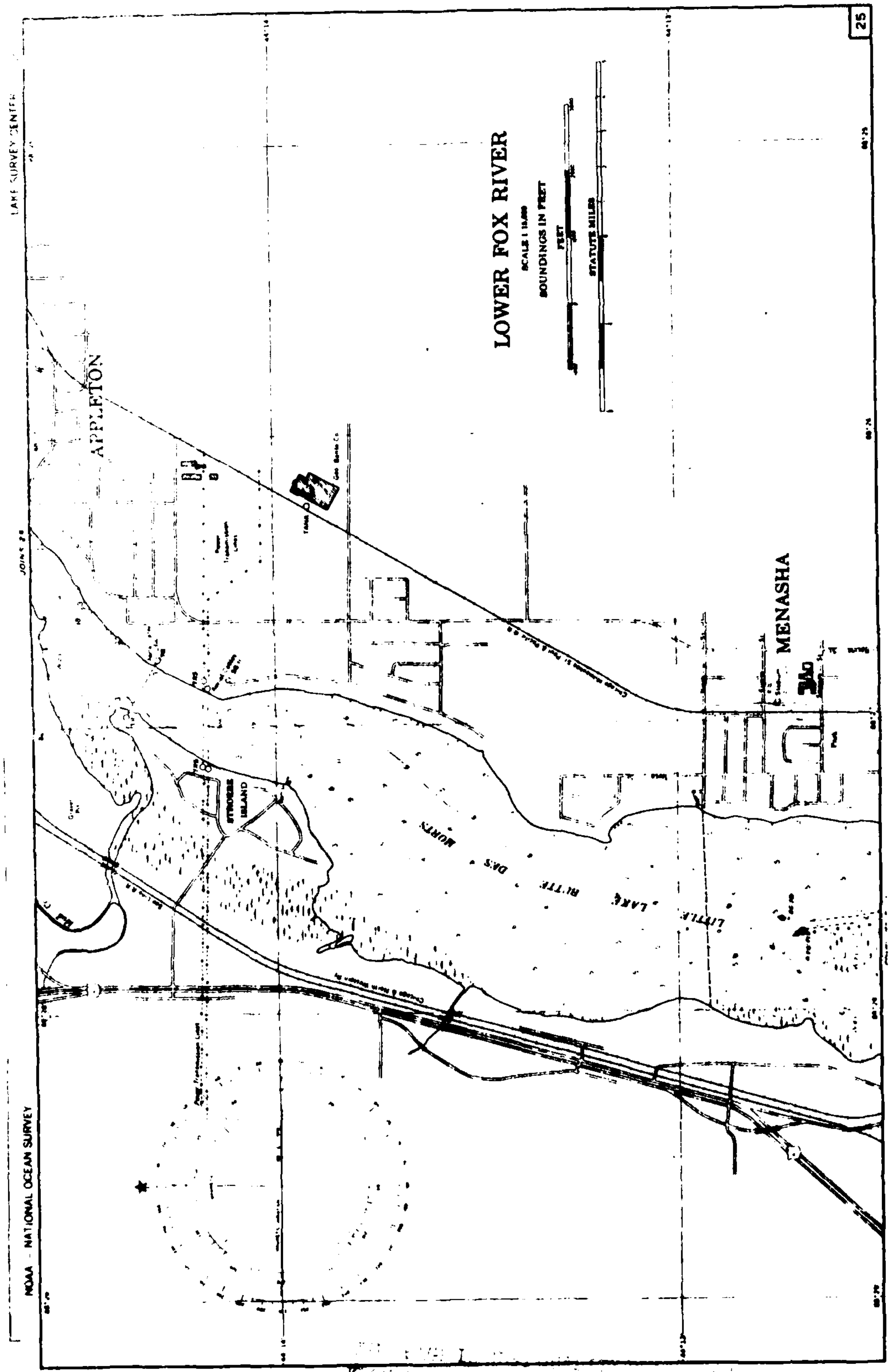

LAKE SURVEY CENTER
WRIGHTSTOWN
30

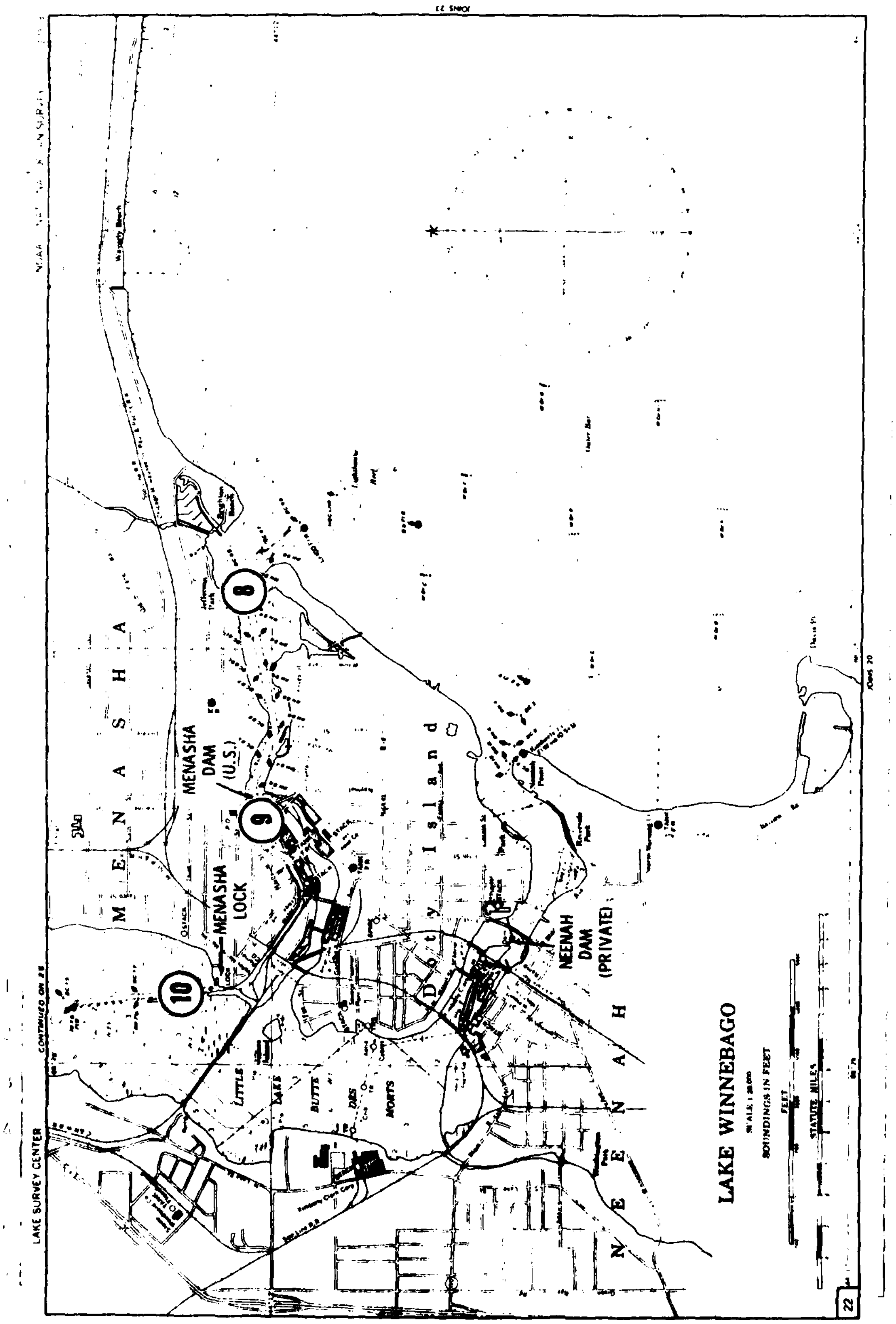

LOWER FOX RIVER
SOUNDINGS IN FEET
STATUTE MILES
29
RAPIDE CROCHE LOCK
RAPIDE CROCHE DAM (U.S.)
21
22
NOAA — NATIONAL OCEAN SURVEY

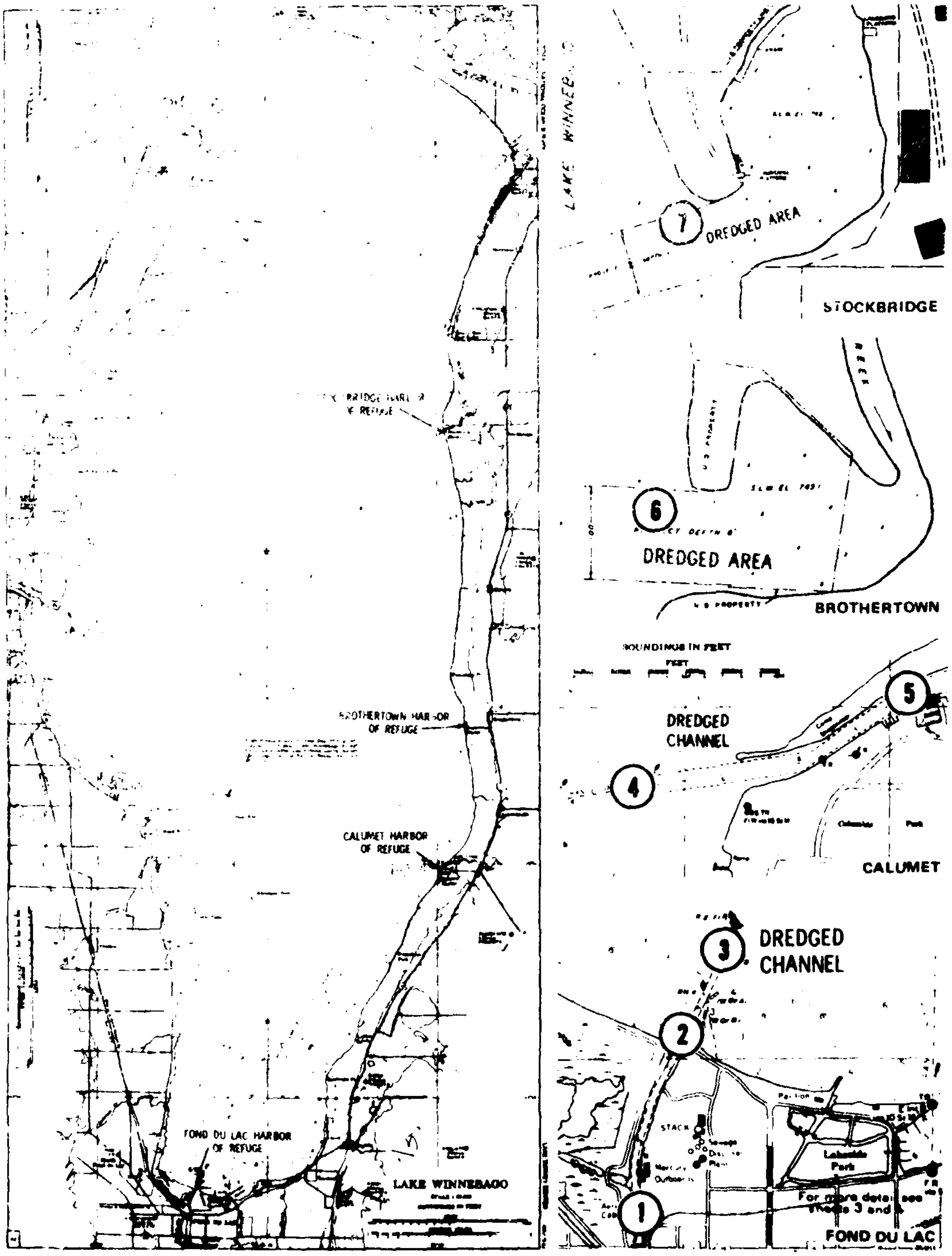

LAKE SURVEY CENTER
NOAA – NATIONAL OCEAN SURVEY
LOWER FOX RIVER
SOUNDINGS IN FEET
FEET
STATUTE MILES
KAUKAUNA LOCKS
NO. 5
NO. 4
NO. 3
NO. 2
NO. 1
GUARD LOCK
KAUKAUNA LOWER DAM (PRIVATE)
KAUKAUNA UPPER DAM (U.S.)
KAUKAUNA
COMBINED LOCKS (UPPER & LOWER)
LITTLE CHUTE
COMBINED LOCKS
18
19
20
28


LOWER FOX RIVER
SOUNDINGS IN FEET
STATUTE MILES
27
NOAA - NATIONAL OCEAN SURVEY
LAKE SURVEY CENTER
KIMBERLY
CEDARS LOCK
CEDARS DAM (U.S.)
LITTLE CHUTE GUARD LOCK
LITTLE CHUTE LOCK NO. 2
LITTLE CHUTE DAM (U.S.)
COMBINED LOCKS DAM (PRIVATE)
COMBINED LOCKS
14
15
16
17


LAKE SURVEY CENTER
NOAA NATIONAL OCEAN SURVEY
LOWER FOX RIVER
SOUNDINGS IN FEET
FEET
STATUTE MILES
APPLETON
APPLETON LOWER DAM (U.S.)
APPLETON MIDDLE DAM (PRIVATE)
APPLETON UPPER DAM (U.S.)
APPLETON LOCKS
NO. 1
NO. 2
NO. 3
NO. 4
11
12
13
26


LOWER FOX RIVER
SOUNDINGS IN FEET
FEET
STATUTE MILES
APPLETON
MENASHA
STROEBE ISLAND
LITTLE LAKE BUTTE DES MORTS
LAKE SURVEY CENTER
NOAA - NATIONAL OCEAN SURVEY
25


LAKE WINNEBAGO
SOUNDINGS IN FEET
FEET
STATUTE MILES
LAKE SURVEY CENTER
MENASHA
NEENAH
Doty Island
LITTLE LAKE BUTTE DES MORTS
MENASHA DAM (U.S.)
MENASHA LOCK
NEENAH DAM (PRIVATE)
10
9
8
22


LAKE WINNEBAGO
FOND DU LAC HARBOR OF REFUGE
CALUMET HARBOR OF REFUGE
BROTHERTOWN HARBOR OF REFUGE
7
DREDGED AREA
STOCKBRIDGE
6
DREDGED AREA
BROTHERTOWN
SOUNDINGS IN FEET
DREDGED CHANNEL
5
4
CALUMET
3
DREDGED CHANNEL
2
STACK
Lakeside Park
1
FOND DU LAC

APPENDIX B: SEDIMENT AND WATER QUALITY

Table B.1. Location and Nature of Dredge Material Specimens for the Fox River, Wisconsin Navigation Project

Specimen No.[a]	Location	Nature of Sample
1	Fond du Lac River, 500 ft downstream from U.S. 45, channel center	Black silt
2	Fond du Lac River, channel mouth and center	Sand, silt leaves, organic matter, blackish color
3	Fond du Lac River channel about 1600 ft into lake	Black silt with about 2 cm oxidized layer on top. Strong sulfide odor
4	Calumet Harbor channel, 600 ft offshore	Medium sand with pieces of organic debris
5	Calumet Harbor channel opposite boat dock	Dark brown to black organic silt
6	Brothertown Harbor-Lake Winnebago between buoys outside of harbor	Silt, clay, sticks and leaves
7	Stockbridge Harbor-Lake Winnebago, 20 yds out from entrance	Sand, silt, some organic material and gravel
8	Lower Fox River Menasha channel between buoys 93-94 and 95-96	Hard bottom - no sample
9	Menasha channel, above Strang Paper Co.	Rocks, sand and pebbles
10	Little Lake Butte des Morts between two islands, about 1000 ft below lock	Organic silt, gas re-leases, fibers present
11	Fox River, 100 ft above #1 lock at Appleton	Black organic silt and sand. Bloodworm present
12	Fox River, 600 ft above College Ave. bridge, Appleton	Sand, large and small gravel
13	Fox River, 600 ft below #4 lock	Sand pebbles and gravel, some organic
14	Fox River, Mid Channel off Sunset Point	No sample - hard bottom
15	Fox River, 400 ft above Cedars lock, Kimberly	Black silt, high organic, sulfide odor
16	Fox River, 150 ft above guard lock, Little Chute	Black silt, high organic, fibrous material

Table B.1. Continued

Specimen No.[a]	Location	Nature of Sample
17	Fox River, foot of Buchanan St., Little Chute	Black silt and organic material
18	Fox River, Exit channel of Combined Locks	No sample - hard bottom
19	Fox River, 100 ft above guard lock, Kaukauna	Blackish silt, sticks and leaves
20	Fox River, 600 ft below lock #5, Kaukauna. Below outfall from Thimony Paper Co. settling pond	Black silt, high organic, paper scraps and gas release and sulfide odor from bottom
21	Fox River, 500 ft above Rapid Croche lock	Black silt and high organic
22	Fox River, 800 ft below Rapid Croche lock	Very fine organic silt, fibers and sticks. Sulfide odor
23	Fox River, 400 ft above Little Kaukauna lock	Black silt, very fine organic material, gas release
24	Fox River, 150 ft below lock at 8 St.-De Pere	Sand, gravel and sticks
25	North intersection of Boom Cut and Wolf River	Fine sand with small amount of organic debris
26	Wolf River MP 34 above Red Banks	Clean sand with a few shells and detritus
27	Wolf River below Devils Elbow, ca. milepost 43	Clean sand
28	Wolf River, Shaw Landing	Coarse sand
29	Wolf River, below entrance of Little Wolf River	Coarse sand and gravel, sticks and bark
30	Wolf River below New London Yacht Club ca. milepost 53	Medium to fine sand, some detritus

[a] *The specimen number is shown on the maps in Appendix A of this report at the location where the specimen was taken.*

Table B.2. Analytical Tests Performed on Dredge-Material Specimens and Characteristics of the Sediments

TESTS PERFORMED

A. General Properties

1. Percent solids
2. pH
3. Conductivity (total salt content)
4. Weight loss on ignition (500°C)
5. Organic carbon (COD)
6. Organic nitrogen
7. Nitrate nitrogen
8. Ammonium nitrogen
9. Oil and grease

B. Mineral Content

10. Exchangeable Ca, Mg, Na
11. Available P, K, B, Mn, Zn, Cu, SO_4-S

C. Total Macroscopic Elements

12. P, K, Ca, Mg, Na, Al, Fe

D. Total Trace Elements

13. B, Sr, B, Cu, Zn, Mn, Cr, Hg, Pb

E. Particle Size Analysis

14. Sand, silt, clay, and sieve analyses

Table B.3. CHARACTERISTICS OF SEDIMENTS

A. General Properties

Sample No.	Solids, %	pH	Cond.[a]	Wt. Loss on Ign., %	Organic C, %	Organic N, ppm	Nitrate N, ppm	Ammonium N, ppm	Oil and Grease, g/kg
1	50.1	7.6	48	10.0	3.8	2745.7	10.7	156.3	2.373
2	55.7	7.9	35	6.0	1.5	1236.7	2.0	19.3	-
3	43.4	7.5	65	9.3	3.4	3136.7	7.3	69.3	0.226
4	74.2	7.5	40	2.6	0.4	474.7	1.7	7.3	-
5	50.3	7.5	45	11.0	3.6	2010.3	2.0	65.7	0.186
6	31.4	7.6	57	19.2	6.5	5645.7	16.7	88.3	0.448
7	64.8	8.3	25	4.3	0.5	499.0	1.3	9.0	-
9	97.3	9.0	35	1.6	0.3	117.7	0.7	4.3	-
10	15.6	7.3	75	25.8	11.8	9984.3	0.7	43.7	0.130
11	52.3	7.5	70	5.8	1.4	1438.3	0.3	7.7	-
12	80.1	8.6	60	2.7	0.5	245.0	0.7	1.0	-
13	87.9	8.3	65	4.2	0.9	384.3	1.0	3.7	-
15	25.0	7.3	65	20.8	8.7	4770.3	5.0	67.7	1.215
16	20.8	7.3	110	23.1	10.1	5647.3	2.7	26.7	-
17	39.0	7.4	115	22.7	4.8	3730.0	2.0	56.0	-
19	20.0	7.3	70	20.3	8.6	5213.7	>0.01	22.3	1.123
20	20.6	7.4	115	23.2	11.3	5730.0	4.0	136.0	0.105
21	19.0	7.3	70	21.7	9.9	5275.3	0.7	100.7	0.275
22	29.3	7.4	75	14.6	5.1	4345.0	4.3	183.0	-
23	24.9	7.3	75	17.3	7.6	5672.7	8.0	219.3	0.105
24	54.7	7.2	115	8.5	2.3	1401.7	3.3	14.3	-
25	79.0	8.3	10	3.1	0.3	337.7	0.3	2.3	-
26	77.2	8.3	10	1.8	0.2	200.2	>0.01	1.7	-
27	92.5	8.4	10	2.5	0.1	53.7	0.7	0.3	-
28	81.0	8.5	10	1.8	0.1	83.3	0.7	0.7	-
29	79.0	8.2	10	2.2	0.3	133.7	1.3	0.7	
30	82.2	8.1	10	1.4	0.1	52.0	2.7	>0.01	-

[a] *Conductivity - mhos x 10^{-5}/cm.*

Table B.4. CHARACTERISTICS OF SEDIMENTS

B. Mineral Content

Sample No.	Exchangeable, ppm			Available, ppm						
	Ca	Mg	Na	P	K	B	Mn	Zn	Cu	SO_4-S
1	2901.5	741.8	54.2	47.1	158.0	1.8	32.3	29.7	0.6	191.6
2	1608.8	371.3	31.7	48.5	128.7	0.8	30.2	11.6	0.5	54.5
3	2720.0	640.0	128.0	160.0	153.6	1.2	23.0	14.7	0.6	122.9
4	1087.5	195.8	20.9	29.6	39.2	0.3	33.9	2.3	0.4	67.0
5	2440.0	823.5	42.7	67.1	192.2	0.7	49.4	6.7	0.6	47.6
6	3532.5	1020.5	62.8	12.6	255.1	1.3	45.5	7.1	0.8	69.1
7	1086.3	158.0	19.0	23.7	39.5	0.4	28.0	2.3	0.4	27.3
9	843.8	318.8	30.0	2.6	37.5	0.6	9.8	1.8	0.4	31.5
10	4271.3	1005.0	80.4	180.9	251.3	2.0	29.1	68.3	7.5	420.1
11	1057.5	188.0	22.6	58.8	58.8	0.5	19.7	41.4	4.7	67.2
12	740.0	277.5	29.6	25.9	55.5	0.5	12.6	9.3	>0.1	73.3
13	1640.0	346.0	41.0	0.8	41.0	0.5	10.7	7.6	>0.1	162.4
15	4575.0	594.8	73.2	358.7	91.5	1.7	19.2	91.5	0.9	302.0
16	4350.0	696.0	71.3	348.0	130.5	1.7	18.3	139.2	0.9	612.5
17	3120.0	741.0	62.4	144.3	136.5	0.9	20.3	112.3	6.2	892.3
19	4016.3	850.5	77.5	642.6	160.7	1.7	22.7	143.6	3.8	426.2
20	4425.0	752.3	106.2	190.3	154.9	1.6	16.8	141.6	3.1	340.7
21	4140.0	782.0	104.9	625.6	161.0	1.7	22.1	161.9	6.0	242.9
22	3633.8	769.5	77.0	321.5	192.4	1.5	22.2	51.3	>0.1	188.1
23	4500.0	855.0	90.0	442.8	211.5	1.7	21.6	165.6	0.9	188.1
24	1500.0	225.0	48.0	144.0	75.0	0.8	13.0	50.0	3.0	192.5
25	743.8	127.5	12.8	31.9	42.5	0.4	42.2	4.5	1.1	30.6
26	682.5	117.0	10.9	19.5	35.1	0.4	39.0	2.7	1.0	23.0
27	308.0	38.5	6.9	17.3	34.7	0.3	21.2	1.4	0.8	6.9
28	281.3	37.5	6.8	15.8	33.8	0.3	17.6	1.8	0.8	6.8
29	570.0	76.0	10.6	30.4	34.2	0.3	35.0	2.1	0.8	14.4
30	281.3	37.5	6.8	13.1	31.9	0.3	19.5	1.8	0.8	5.3

Table B.5. CHARACTERISTICS OF SEDIMENTS

C. Total Macroscopic Elements

Sample No.	P	K	Ca	Mg	Na	Al	Fe
	percent						
1	0.731	1.49	0.724	1.71	0.281	0.533	1.48
2	0.602	1.37	1.62	1.91	0.313	0.985	1.18
3	0.579	1.17	1.55	1.44	0.266	0.913	1.02
4	0.598	1.51	4.44	4.39	0.453	0.286	1.15
5	0.786	1.79	0.703	1.11	0.266	1.83	1.65
6	0.536	1.13	0.947	0.812	0.210	1.10	1.03
7	0.927	1.50	4.54	3.88	0.369	0.444	1.93
10	0.314	0.594	0.847	0.453	0.107	0.901	0.4750
11	0.437	1.39	1.12	1.07	0.290	1.16	0.8510
15	0.342	0.572	1.27	0.391	0.103	1.09	0.6220
16	0.332	0.516	1.12	0.385	0.103	1.09	0.5900
17	0.629	1.40	1.29	1.12	0.222	1.87	1.2800
19	0.380	0.729	0.947	0.488	0.132	1.3	0.629
20	0.329	0.665	0.675	0.341	0.112	1.09	0.460
21	0.500	0.988	0.984	0.603	0.153	1.80	1.03
22	0.538	1.15	0.958	0.652	0.199	1.81	1.04
23	0.414	0.901	0.930	0.470	0.157	1.43	0.737
24	0.516	1.40	2.39	1.44	0.342	1.18	0.878
25	0.387	1.52	1.04	0.615	0.338	1.63	0.732
26	0.364	1.16	0.659	0.384	0.318	1.47	0.695
27	0.256	1.23	0.566	0.326	0.329	1.34	0.396
28	0.335	1.70	0.404	0.236	0.481	1.70	0.639
29	0.477	1.65	0.669	0.347	0.456	1.73	0.964
30	0.314	0.916	0.430	0.266	0.300	1.18	0.612

Samples 9, 12, 13 not run.

Table B.6. CHARACTERISTICS OF SEDIMENTS

D. Total Trace Elements

Sample No.	Ba	Sr	B	Cu	Zn	Mn	Cr	Hg	Pb
	parts per million								
1	138.	86.6	79.3	41.7	112.	358.	118.	0.15	62.2
2	145.	77.4	64.8	22.2	50.4	352.	57.3	0.11	8.26
3	173.	81.8	78.5	25.0	67.1	278.	243.	0.22	26.2
4	130.	83.7	64.7	14.4	25.9	377.	33.8	<0.05	8.22
5	196.	55.5	98.2	24.2	50.1	344.	34.3	<0.05	6.39
6	139.	47.0	59.8	17.7	38.2	294.	28.	<0.05	5.24
7	104.	72.7	93.9	19.9	41.2	453	45.4	<0.05	2.92
10	74.6	17.7	31.3	35.4	54.1	108.	18.5	0.17	31.2
11	200.	61.5	42.8	22.8	65.3	221.	19.5	0.17	28.6
15	87.6	33.5	32.1	38.2	77.0	102.	24.3	0.23	55.6
16	78.8	32.4	32.4	33.6	101.	99.	28.6	0.33	39.5
17	170.	65.8	73.5	45.0	157.	213.	59.	0.57	53.4
19	95.7	36.1	39.	36.4	107.	114.	62.4	0.47	62.8
20	76.7	20.9	29.5	32.9	86.	94.4	38.2	1.25	57.6
21	146.	47.6	58.9	26.3	89.	176.	42.5	0.28	24.1
22	134.	52.8	60.9	29.3	92.	181.	46.9	0.34	25.2
23	111.	32.9	41.5	30.9	119.	148.	50.2	0.47	35.0
24	199.	139.	59.9	91.3	169.	161.	32.5	0.24	242.
25	254.	66.1	44.8	9.78	22.4	231.	18.9	<0.05	1.36
26	204.	52.	39.	8.58	20.2	196.	13.3	<0.05	1.42
27	180.	41.2	26.9	9.09	13.7	119.	12.2	<0.05	0.85
28	240.	46.8	36.1	9.52	21.8	165.	16.2	<0.05	0.85
29	226.	60.7	53.1	12.7	24.3	222.	17.7	<0.05	0.64
30	150.	45.8	30.7	7.08	26.9	173.	10.7	<0.05	0.86

Table B.7. CHARACTERISTICS OF SEDIMENTS

E. Particle Size Analysis

Sample No.	Sand, % (0.05-2 mm)	Silt, % (0.002-0.05 mm)	Clay, % (<0.002 mm)
1	20	48	32
2	67	21	12
3	35	44	20
4	53	44	3
5	34	36	30
6	8	66	26
7	91	6	3
9	*	*	*
10	23	63	14
11	87	8	5
12	*	*	*
13	*	*	*
15	43	44	13
16	47	41	12
17	23	58	19
19	36	46	18
20	31	55	14
21	37	48	15
22	1	63	36
23	28	46	26
24	92	6	2
25	93	5	2
26	94	4	2
27	99	1	0
28	100	0	0
29	96	2	2
30	100	0	0

Sieve Analyses of Samples 9, 12 and 13[a]

Sample No.	>2380μ sieve, %	Percent Passing 2380μ sieve	840μ sieve	250μ sieve	149μ sieve
9	98.6	1.4	0.7	0.3	0.1
12	68.7	31.3	11.0	2.0	0.9
13	92.1	7.9	3.1	0.9	0.5

[a] *Because of the stoniness of these samples, sieve analyses were performed.*

Table B.8. Chemical Properties of Highly Polluted Bottom Sediments

Parameter	Range	Mean
Total volatile solids (%)	10.2 - 49.3	19.6
Chemical oxygen demand (g/kg)	39.0 -395	177.0
Kjeldahl nitrogen (g/kg)	0.58- 6.80	2.64
Total phosphorous (g/kg)	0.59- 2.55	1.06
Grease and oil (g/kg)	1.38- 32.1	7.15
Initial oxygen demand (g/kg)	0.28- 4.65	2.07
Sulfides (g/kg)	0.10-377	1.70

Source: G. O'Neal and J. Sceva, 1971, "The Effects of Dredging on Water Quality in the Northwest," U. S. Environmental Protection Agency, Office of Water Programs, Region X, Seattle, Washington.

TABLE 3.[illegible] CRITERIA FOR DETERMINING ACCEPTABILITY OF DREDGED MATERIAL DISPOSAL TO THE NATION'S WATERS

Use of Criteria

These criteria were developed as guidelines for FWQA evaluation of proposals and applications to dredge sediments from fresh and saline waters.

Criteria

The decision whether to oppose plans for disposal of dredged material in U.S. waters must be made on a case-by-case basis after considering all appropriate factors; including the following:

(a) Volume of dredged material.
(b) Existing and potential quality and use of the water in the disposal area.
(c) Other conditions at the disposal site such as depth and currents.
(d) Time of year of disposal (in relation to fish migration and spawning, etc.).
(e) Method of disposal and alternatives.
(f) Physical, chemical, and biological characteristics of the dredged material.
(g) Likely recurrence and total number of disposal requests in a receiving water area.
(h) Predicted long and short term effects on receiving water quality.

When concentrations, in sediments, of one or more of the following pollution parameters exceed the limits expressed below, the sediment will be considered polluted in all cases and, therefore, unacceptable for open water disposal.

Sediments in Fresh and Marine Waters	Conc. % (dry wt. basis)
*Volatile Solids	6.0
Chemical Oxygen Demand (C.O.D.)	5.0
Total Kjeldahl Nitrogen	0.10
Oil-Grease	0.15
Mercury	0.0001
Lead	0.005
Zinc	0.005

*When analyzing sediments dredged from marine waters, the following correlation between volatile solids and C.O.D. should be made:

$$T.V.S.\ \%\ (dry) = 1.32 + 0.98\ (C.O.D.\%)$$

If the results show a significant deviation from this equation, additional samples should be analyzed to insure reliable measurements.

The volatile solids and C.O.D. analyses should be made first. If the maximum limits are exceeded the sample can be characterized as polluted and the additional parameters should not have to be investigated.

Dredged sediment having concentrations of constituents less than the limits stated above will not be automatically considered acceptable for disposal. A judgment must be made on a case-by-case basis after considering the factors listed in (a) through (h) above.

In addition to the analyses required to determine compliance with the stated numerical criteria, the following additional tests are recommended where appropriate and pertinent:

Total Phosphorus
Total Organic Carbon (T.O.C.)
Immediate Oxygen Demand (I.O.D.)
Settleability
Sulfides
Trace Metals (iron, cadmium, copper, chromium, arsenic, and nickel)
Pesticides
Bioassay

The first four analyses would be considered desirable in almost all instances. They may be added to the mandatory list when sufficient experience with their interpretation is gained. For example, as experience is gained, the T.O.C. test may prove to be a valid substitute for the volatile solids and C.O.D. analyses. Tests for trace metals and pesticides should be made where significant concentrations of these materials are expected from known waste discharges.

All analyses and techniques for sample collection, preservation and preparation shall be in accord with a current FWQA analytical manual on sediments.

TABLE B.10. INTERIM TEST PROCEDURES FOR ASSESSING THE SUITABILITY OF DREDGED OR FILL MATERIAL

TYPE OF TEST AND GENERAL ANALYTICAL STEPS	INTERPRETATION OF RESULTS
1. Elutriate Test* a. Mix one volume of bottom sediment from the dredging site with four volumes of water from the dredging site. b. Shake vigorously for 30 minutes. c. Allow the sample to settle for one hour. d. Centrifugate and filtrate through a 0.45 micron filter. e. The resulting supernatant is analyzed for major constituents.	1. If the concentration of major constituents in supernatant is more than 1.5 times the concentration of the same constituents in the water from the proposed site after a dilution factor of 10 is applied, then restricted disposal conditions will apply. 2. If the suspended material (g/l) is a major constituent, the following procedure is followed: a. Withdraw one volume of 1:4 sediment-to-water slurry (from elutriation test) immediately after the 30-minute shaking. b. Disperse the above volume of slurry within 10 volumes of water from the proposed discharge site. c. Allow to settle for one hour and analyze the uppermost layer gravimetrically for suspended solids. d. Determine the suspended sediment concentration at the proposed discharge site. e. Compare the above results and, if the concentration from the slurry sample is less than 1.5 times the sediment at the discharge site, the dredged material may be discharged at the disposal site.
2. Sediment Analysis* a. Weigh a portion of dredged or fill material. b. Extract inorganic constituents by using a concentrated strong acid. c. Extract organic constituents by using organic solvents.	

*A manual will be prepared and published jointly by the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers detailing the sampling and testing procedures.

SOURCE: U.S. Environmental Protection Agency, 1975. Guidelines for Discharge of Dredged or Fill Material in Navigable Waters. Federal Register, May 6, 1975.

Table B.11. Water Quality Parameters for the Wolf River (mg/liter except where noted)

		Keshena[a]	Keshena[b]	Above New London[a]	New London[a]	Fremont[a]	Fremont[b]	Winneconne[a]	Waupaca[a]
Dissolved oxygen	Avg	10.8	11.2	8.7	8.0	8.9	8.6	9.7	10.9
	Range	7.9-13.9	7.9-135	4.9-11.8	3.8-13.4	4.2-13.4	4.2-13.4	6.4-14	5.5-13.5
pH[c]	Avg	8.0	7.8	7.7	7.8	7.8	7.7	8.0	8.3
	Range	7.4-8.4	7.2-8.2	7.1-8.3	7.1-8.2	7.1-8.4	7.1-8.3	7.1-8.9	7.5-9.0
Alkalinity as $CaCo_3$	Avg	105	97	124	148	141	145	146	172
	Range	66-150	48-132	97-164	104-244	102-182	102-182	106-344	134-206
Cl	Avg	2.2	0.6	5.1	5.6	4.9	4.0	5.9	4.9
	Range	0-6.4	0-3.5	0-15	0.3-9.9	1.5-9.4	0-7	3-11	2.5-7.9
Hardness as CO_3	Avg	110	108	135	164	159	184	164	187
	Range	50-164	46-152	106-169	100-256	104-264	94-312	120-312	141-223
SO_4	Avg	9.7		15	18	18		18	13
	Range	3.2-19		3.2-32	0.8-47	6.6-29		1.5-31	6.9-21
Color[d]	Avg	62	39	70	70	73	40	60	37
	Range	17-130	8-120	15-125	20-130	20-130	6-120	28-130	8-100
Soluble P	Avg	0.01		0.03	0.04	0.03		0.01	0.03
	Range	0.01-0.04		0.0-0.04	0.01-0.16	0-0.09		0-0.06	0-0.08
Total P	Avg	0.03	0.05	0.08	0.1	0.08	0.15	0.09	0.1
	Range	0.01-0.06	0.02-0.16	0.03-0.12	0.06-0.21	0.04-0.13	0.06-0.58	0.01-0.26	0.01-0.16
NO_3	Avg	0.8	0.22	1.0	2.1	1.6		1.4	4.2
	Range	0-4.3	0.08-1.4	0-3.5	0-8.3	0-5.8		0-5.2	0-8.3
Specific conductivity[e]	Avg	201		258	274	278		287	345
	Range	141-323		213-311	232-346	224-380		228-361	283-417
Turbidity[f]	Avg	190		286	200	600		1200	500
	Range	100-500		120-1000	100-550	130-2200		160-7500	100-900
Fecal coliform[g]	Avg		10				5		
	Range		5-900				5-2400		
5-day BOD	Avg		1.5				1.7		
	Range		1-3				0.6-10		
Suspended solids	Avg		8				15		
	Range		1-48				2-42		
Total solids	Avg		148				225		
	Range		98-210				168-414		

[a] From "Water Quality and Flow of Streams in Northeastern Wisconsin," Northeastern Wisconsin Regional Planning Commission, Appleton, Feb. 1970.

[b] From "State of Wisconsin, Surface Water Quality Monitoring 1969-1972," Wisconsin Department of Natural Resources.

[c] pH units

[d] Units not reported.

[e] [illegible]

[f] Jackson Turbidity Units.

[g] No./liter.

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Table B.12. Physical and Chemical Characteristics of Lake Winnebago

Parameter	Vicinity of				
	Oshkosh		Fond du Lac		
	Aug 74	Nov 74	Jun 74	Aug 74	Nov 74
Temperature (Cent.)	23.6	36.2	16.4	22.9	7.0
Dissolved oxygen (mg/l)	7.0	9.3	15.6	4.1	10.4
Conductivity (μmhos)	270	360	305	510	590
pH (units)	8.55	7.80	8.10	7.30	8.00
Alkalinity (mg/l)	125	152	143	163	216
Total P (mg/l)	0.084	0.055	0.277	0.944	0.134
Dissolved P (mg/l)	0.039	0.033	0.108	0.728	0.096
$NO_2 + NO_3$ (mg/l)	0.090	0.390	0.150	01.080	01.030
Ammonia (mg/l)	0.120	0.100	0.110	01.220	0.300
Secchi disc (inches)	20	18		16	17
	Neenah		Stockbridge		
	Aug 74	Nov 74	Jun 74	Aug 74	Nov 74
Temperature (Cent.)	22.1	6.1	19.3	22.4	6.0
Dissolved oxygen (mg/l)	9.7	10.6	15.2	10.5	11.5
Conductivity (μmhos)	280	320	300	250	330
pH (units)	8.9	7.9	8.8	9.05	8.30
Alkalinity (mg/l)	131	139	140	119	137
Total P (mg/l)	0.090	0.078	0.154	0.179	0.080
Dissolved P (mg/l)	0.054	0.047	0.112	0.107	0.043
$NO_2 + NO_3$ (mg/l)	0.070	0.230	0.060	0.090	0.240
Ammonia (mg/l)	0.060	0.160	0.100	0.050	0.130
Secchi disc (inches)	44	21	12	40	18

*Source: *U. S. Environmental Protection Agency National Eutrophication Survey Working Paper #57, January, 1975.*

Table B.13. Physical and Chemical Characteristics of Upriver Lakes

Parameter	Lake Poygan[a]			Lake Winneconne[a]			Lake Butte des Morts[b]		
	Jun 72	Aug 72	Nov 72	Jun 72	Aug 72	Nov 72	Jun 72	Aug 72	Nov 72
Temperature (Cent.)	9.4	23.7	6.2	18.3	23.7	6.2	18.0	23.6	5.9
Dissolved oxygen (mg/l)	8.7	8.4	10.4	9.9	7.4	10.4	8.0	7.5	10.5
Conductivity (μmhos)	285	358	325	270	275	335	270	263	330
pH (units)	8.30	8.60	7.70	8.60	8.50	7.70	7.9	8.6	7.9
Alkalinity (mg/l)	155	130	139	149	131	137	148	131	142
Total P (mg/l)	0.163	0.075	0.080	0.088	0.079	0.074	0.048	0.105	0.028
Dissolved P (mg/l)	0.050	0.025	0.043	0.024	0.026	0.041	0.018	0.032	
$NO_2 + NO_3$ (mg/l)	0.220	0.060	0.460	0.070	0.060	0.450	0.120	0.060	0.390
Ammonia (mg/l)	0.110	0.050	0.070	0.100	0.070	0.060	0.110	0.190	0.090
Secchi disc (inches)	18	17	17		18	21	30	20	19

[a] *U. S. Environmental Protection Agency National Eutrophication Survey Working Paper #45, November, 1974.*

[b] *U. S. Environmental Protection Agency National Eutrophication Survey Working Paper #35, January, 1975.*

Table B.14. **Sources of Pollution Locations on the Lower Fox River**

No.	Source	River Mile	Pounds BOD/Day[a]
1	Gilbert Paper Company	39.8	3
2	John Strange Paper Company	39.8	902
3	George A. Whiting Paper Company	38.7	446
4	Bergstrom Paper Company	39.8	17,322
5	Kimberly-Clark, Neenah Div.	40.1	316
6	Kimberly-Clark, Badger Globe	39.9	0
7	Kimberly-Clark, Lakeview	39.2	1,531
8	Neenah-Menasha, Cities of	37.6	2,080
9	Riverside Paper Corporation	33.3	420
10	Consolidated Papers, Inc.	32.1	39,113
11	Appleton, City of	30.0	5,890
12	Kimberly Clark Corp.	29.0	6,695
13	Kimberly, Village of	27.0	90
14	Combined Paper Mills, Inc.	27.0	0
15	Kaukauna, City of	23.1	255
16	Thilmany Pulp & Paper Company	23.0	16,041
17	Wrightstown, Village of	16.8	40
18	Nicolet Paper Company	7.0	553
19	U. S. Paper Mills Corporation	6.8	0
20	De Pere, City of	6.2	1,065
21	Fort Howard Paper Company	3.7	4,678
22	American Can Company	1.4	56,675
23	Charmin Paper Products Company	1.0	45,020
24	Green Bay Packaging, Inc.	.8	940
25	Green Bay, City of	.1	16,200
		Total	216,275

[a] *BOD data taken from the Lower Fox River Drainage Basin Report, 1968, and the November, 1973, NR 101 Pulp and Paper Summary Reports.*

Table B.15. Fox River Lake Winnebago Outlet, 1974-1975
Storet Station Number 713002

Parameter	No. of Samples	Mean	Range Min	Range Max
Water temp., °C	20	11.25	0.00	25.00
Color, Pt-Co units	19	21.58	15.00	30.00
DO, mg/l	20	11.33	6.60	14.50
5-day BOD, mg/l	18	3.31	0.60	8.20
6-day BOD, mg/l	1	9.20	9.20	9.20
pH, SU	20	8.38	7.90	9.30
Lab. pH, SU	5	8.32	7.80	9.00
Tot. alk., $CaCO_3$, mg/l	19	152.32	128.00	178.00
Tot. residue, mg/l	15	229.87	200.00	254.00
Tot. vol. residue, mg/l	8	5.00	0.00	12.00
Tot. nflt. residue, mg/l	15	9.67	0.00	29.00
Vol. nflt residue, mg/l	7	4.71	0.00	15.00
Org. N as N, mg/l	19	0.71	0.34	1.59
Tot. NH_3 as N, mg/l	19	0.11	0.01	0.29
Dis. NO_3 as N, mg/l	12	0.17	0.02	0.33
Tot. NO_2 + NO_3 as N, mg/l	7	0.24	0.01	0.41
Tot. phosphate, as P, mg/l	18	0.09	0.04	0.19
Dis. o-phosphate, as P, mg/l	7	0.04	0.004	0.12
Tot. hardness, $CaCO_3$, mg/l	19	174.19	143.00	200.00
Chloride, as Cl, mg/l	19	8.05	6.00	14.00
Total sulfate, mg/l	1	18.00	18.00	18.00
Fecal coli (M-FC agar), No./100ml	16	21.88	10.00	70.00

Table B.16. Seasonal Water Quality Data for the Lower Fox River[a]

	Avg. Flow, ft^3/sec[b]	Ortho PO_4, lb/day	Total P as PO_4 lb/day	NO_3-N, lb/day	NH_3-N lb/day	Total N[c], lb/day	COD. lb/day	Suspended Solids, lb/day
				From Lake Winnebago[d]				
June-Aug.	2330	786	7,730	1,280	1,890	123,000	403,000	210,000
Sept.-Nov.	3220	3520	5,800	5,650	5,800	67,100	399,000	197,000
Dec.-Feb.	4010	1680	4,100	8,620	4,100	94,500	454,000	65,200
March-May	6600	2290	8,830	24,200	8,800	326,000	916,000	436,000
Annual Avg.	4040	2070	6,620	9,940	5,200	153,000	543,000	229,000
				Above Green Bay[d]				
June-Aug.	2330	616	6,920	1,900	2,990	278,000	484,000	206,000
Sept.-Nov.	3220	1500	6,920	2,500	3,110	103,000	621,000	149,000
Dec.-Feb.	4010	2530	5,970	5,780	252	135,000	901,000	168,000
March-May	6600	4010	16,900	25,600	22,000	297,000	1,420,000	643,000
Annual Avg.	4040	2160	9,200	8,950	7,100	203,000	857,000	292,000

[a] *From P. E. Sager and J. H. Weirsma, "Nutrient Discharges to Green Bay, Lake Michigan, from the Lower Fox River," Proc. 15th Conf. on Great Lakes Research, 1972.*

[b] *Multiply ft^3/sec by 0.02832 to convert flow to m^3/sec.*

[c] *Data from January 1971 to January 1972.*

[d] *Values are expressed in lb/day; multiply by 0.4536 to convert loadings to kg/day.*

Table B.17. Water Quality of the Fox River at Wrightstown, STORET Station Number 04085000

Parameter	No. of Samples	Mean	Range Min.	Range Max.
Water temp., °C*	8	5.56	0.50	19.00
Inst. stream flow, cfs	7	3711.42	1735.00	7689.89
Turbidity, JTU	6	7.50	3.00	10.00
Conductivity, 25°C, μmho*	8	401.63	303.00	469.99
DO, mg/l*	4	12.33	7.70	15.40
pH, SU*	8	7.47	7.09	7.79
CO_2, mg/l	6	12.23	5.50	25.00
Tot. alk. as $CaCO_3$, mg/l*	7	160.29	130.00	177.00
HCO_3 ion, mg/l*	7	195.43	158.00	216.00
CO_3 ion, mg/l*	4	0.00	0.00	0.00
Periphyton biomass, g/m^2	1	2.30	2.30	2.30
Total nitrogen, mg/l	5	1.20	1.00	1.40
Total kjeldahl N, mg/l	5	0.95	0.77	1.30
Total NO_2 + NO_3 as N, mg/l	6	0.26	0.10	0.31
Total phosphorus, mg/l	6	0.08	0.01	0.11
Total org. carbon, mg/l	2	18.00	14.00	22.00
Total hardness as $CaCO_3$, mg/l*	7	187.00	149.00	210.00
NC hardness as $CaCO_3$, mg/l*	7	26.14	20.00	33.00
Dis. calcium, mg/l*	7	41.86	35.00	46.00
Dis. magnesium, mg/l*	7	19.86	15.00	23.00
Dis. sodium, mg/l*	7	10.71	4.40	16.00
Sodium adsorption ratio*	7	0.34	0.20	0.50
Percent sodium*	7	10.71	6.00	15.00
Dis. potassium, mg/l*	7	2.34	2.00	2.80
Chloride, mg/l*	7	13.57	7.00	18.00
Total sulfate, mg/l*	7	28.00	22.00	34.00
Dis. fluoride, mg/l*	7	0.29	0.10	0.50
Dis. silica, mg/l*	7	6.49	1.30	9.00
Dis. arsenic, μg/l	2	0.50	0.00	1.00
Susp. arsenic, μg/l	1	1.00	1.00	1.00
Total arsenic, μg/l	1	2.00	2.00	2.00
Dis. cadmium, μg/l	2	0.00	0.00	0.00
Susp. cadmium, μg/l	2	1.50	1.00	2.00
Total cadmium, μg/l	2	1.50	1.00	2.00
Dis. chromium, μg/l	2	2.50	2.00	3.00
Susp. chromium, μg/l	2	7.50	7.00	8.00
Total chromium, μg/l	2	10.00	10.00	10.00
Dis. cobalt, μg/l	2	0.50	0.00	1.00
Susp. cobalt, μg/l	2	0.50	0.00	1.00
Total cobalt, μg/l	2	1.00	1.00	1.00
Dis. copper, μg/l	2	1.50	1.00	2.00
Susp. copper, μg/l	2	8.50	7.00	10.00
Total copper, μg/l	2	10.00	8.00	12.00
Total iron, μg/l	2	255.00	180.00	330.00
Dis. iron, μg/l	2	90.00	20.00	160.00
Dis. lead, μg/l	2	5.00	2.00	8.00

Table B.17. Continued

Parameter	No. of Samples	Mean	Range Min.	Range Max.
Susp. lead, μg/l	2	6.50	3.00	10.00
Total lead, μg/l	2	11.50	11.00	12.00
Susp. manganese, μg/l	2	11.50	0.00	23.00
Manganese, μg/l	2	30.00	0.00	60.00
Dis. manganese, μg/l	2	23.50	10.00	37.00
Dis. zinc, μg/l	2	7.00	4.00	10.00
Susp. zinc, μg/l	2	35.00	20.00	50.00
Total zinc, μg/l	2	40.00	20.00	60.00
Dis. selenium, μg/l	2	0.00	0.00	0.00
Susp. selenium, μg/l	2	0.00	0.00	0.00
Tot. selenium, μg/l	2	0.00	0.00	0.00
Fecal coli. MF M-FC Br., No./100 ml	7	198.14	56.99	320.00
Fecal strep. MF M-Ent., No./100 ml	7	83.43	0.00	170.00
Chlor. B, periphtn, mg/m^2	1	0.30	0.30	0.30
Chlor. A, periphtn, mg/m^2	1	2.00	2.00	2.00
Total algae, No./ml	6	3241.67	750.00	8000.00
Dis. residue 180°C, mg/l*	7	235.14	180.00	261.00
Dis. solids SUM, mg/l*	7	219.57	165.00	238.00
Dis. solids, tons/day	6	2008.33	1120.00	2880.00
Dis. solids, tons/acre-ft*	7	0.32	0.24	0.36
Total N as NO_3, mg/l	5	5.32	4.60	6.20
Dis. mercury, μg/l	2	0.05	0.00	0.10
Susp. mercury, μg/l	2	0.10	0.00	0.20
Total mercury, μg/l	2	0.15	0.10	0.20

**1960-1975 sampling period for parameter.*
1974-1975 sampling period for all other parameters.

Table B.18. Final Permit (1977) Loadings for Lower Fox River Waste Sources

Source Name	BOD_5 kg/day (lbs/day)	Suspended Solids kg/day (lbs/day)
K. C. Neenah & Badger Globe	498.9 (1100)	464.8 (1025)
Bergstrom Paper	1077.1 (2375)	1645.3 (3628)
K. C. Lakeview	816.3 (1800)	498.9 (1100)
Neenah Menasha STP	2043.5 (4506)	2043.5 (4506)
Wisconsin Tissue	536.9 (1184)	726.5 (1602)
Menasha Sanit. Dist. E. & W.	359.6 (793)	359.6 (793)
Riverside Paper	394.5 (870)	376.4 (830)
Formost Dairy	49.0 (108)	NA
Consolidated Appleton	1133.8 (2500)	680.3 (1500)
Appleton STP	1859.4 (4100)	1859.4 (4100)
K. C. Kimberly	907.0 (2000)	1360.5 (3000)
Appleton Papers	1655.3 (3650)	1873.0 (4130)
Heart of the Valley STP	601.8 (1327)	601.8 (1327)
Thilmany Paper	2675.7 (5900)	2675.7 (5900)
Wrightstown STP	73.5 (162)	73.5 (162)
Nicolet Paper	589.6 (1300)	440.8 (972)
De Pere STP	1614.0 (3559)	1614.0 (3559)
Fort Howard Paper	3945.5 (8700)	5850.0 (12900)
Charmin Paper	3460.2 (7630)	3854.8 (8500)
Green Bay Packaging	725.6 (1600)	544.2 (1200)
American Can	839.0 (1850)	571.4 (1260)
Green Bay STP	5940.9 (13100)	5940.9 (13100)
George A. Whiting Paper Co.	272.1 (600)	725.6 (1600)
Total	32,069.4 (70715)	34,807.7 (76753)

From D. J. Patterson et al., "Water Pollution Investigation: Lower Green Bay and Lower Fox River," Wisconsin Division of Natural Resources, June 1975.

Table B.19. Industrial Waste Loading (data as available Fall 1972, and subject to continuing change)[a]

Section Number	Industry	Miles above Mouth	Total Production tons/day: Paper	Board	Pulp	Manufacturing Process: Production Process	Product	Fraction of Production %	Treatment Facilities: Primary 1972	Primary Future	Secondary 1972	Secondary Future	Total Effluent: Flow MGD	BOD_5 lb/day	SS lb/day
1	Kimberly-Clark Neenah Division	38.4	50	-	9	VII 2	Bond	100	-	M	-	M	0.7	43	113
2	Kimberly-Clark Badger Globe	38.2	65	-	-	VII 4	Tissue & towels	100	-	M	-	M	0.5	153	346
2	Bergstrom Paper Company	38.1	300	-	300	V VII 3	Book & Bond	50 50	CL-DF	CL-DF	-	M	5.0	21580	11362
4	Gilbert Paper Company	38.0	80	-	-	VII 2	Bond	100	-	M	-	M	0.7	5	2250
5	John Strange Paper Company	37.9	-	300	300	VI	Paperboard	100	-	M	-	M	1.4	960	3056
3	Kimberly-Clark Lakeview	37.5	230	-	-	VII 4	Tissue & towels	100	CL	CL	-	-	4.9	499	246
6	George A. Whiting Company	37.1	20	-	-	VII 2	Bond	100	CL	CL	-	-	0.15	200	
-	Wisconsin Tissue Mills	36.9	85	-	60	V VII 4	Tissue	100	M	M	M	M	-	-	-
13	Riverside Paper Company	31.4	90	-	90	V	Bond	100	-	M	-	M	0.35		
14	Consolidated Paper Interlake Div.	30.6	-	-	155	II	Pulp	100	-	M	-	M	5.3	17840	13300
17	Kimberly-Clark Kimberly	27.3	530	-	45	IV VII 3	Book & Publication	15 85	CL	CL-C	-	-	11.0	18459	48170
20	Appleton Paper Inc.	25.6	480	-	240	IV VII 3	Publication	40 60	-	CL-DF	-	-	5.1	23591	40827
23	Thilmany Paper Company	23.2	515	-	390	I VII 5	Specialty	75 25	-	CL-DF	-	AL	21.0	26157	28061
33	Nicolet Paper Company	7.3	118	-	-	VII_x	Dense Papers	100	CL-DF	CL-DF	-	-	2.5	589	439
-	U. S. Paper Mills	6.9	-	47	47	VI	Paperboard	100	M	M	M	M	-	-	-
39	Fort Howard Paper Company	3.6	850	-	724	V VII 4	Tissue & towels	85 15	-	CL	-	AL-SCL	10.3	52957	30793
41	American Can Company	1.0	450	-	220	II VII 4	Tissue & towels	50 50	SP	SP	-	M	16.6	53158	15979
41	Charmin Paper Company	1.0	997	-	526	II VII 4	Tissue & towels	50 50	C-I	C-I	-	M	12.5	48650	18638
43	Green Bay Packaging	0.7	-	285	215	III	Corregating Medium	100	Closed system		Reverse Osmosis		3.0	4439	1332

[a] From E. F. Joeres et al., "A Guide to Water and Related Land Use in the Lower Fox River Watershed," University of Wisconsin Sea Grant College Program, Special Report #503.

Table B.19. Continued

PRODUCTION PROCESS CODES

I	Kraft pulping and mfg. of coarse paper, liner board, newsprint, bleached and unbleached grades
II	Sulfite pulping and mfg. of paper and dissolving pulp
III	Neutral sulfite semichemical bleached (chemi-groundwood)
IV	Bleached and unbleached groundwood
V	De-inking mill
VI	Paperboard (no de-inking)
VII 2	Mfg. of fine paper (from purchased pulp)
VII 3	Mfg. of book paper (from purchased pulp)
VII 4	Mfg. of tissue paper (from purchased pulp
VII 4*	Mfg. of tissue paper from waste paper and purchased pulp
VII 5	Mfg. of specialty paper (from purchased pulp)
VII_x	Mfg. of greaseproof glassine.

TREATMENT CODES

C = centrifuge
CL = clarifier
DF = disk sludge filter
I = incinerator
AL = aerated lagoon
SCL = secondary clarifier
SP = settling pond
M = to municipal plant

Table B.20. **Chemical Analyses of Water Samples from Five Selected Lower Fox River Sludge Beds June 1970**[a]

	Total Kjeldahl Nitrogen, mg/l	Free Ammonia, as NH_3, mg/l	Nitrate, as NO_3, mg/l	Nitrite, as NO_2, mg/l	Phosphate, as PO_4, mg/l
Water over Top of Sludge					
Sample BW 1	0.11	0.31	0.39	0.01	0.18
Sample BW 6	2.38	0.17	0.29	0.01	0.01
Sample BW 14	0.41	0.55	0.58	0.02	0.05
Sample BW 22	0.45	0.68	0.54	0.01	<0.01
Sample BW 24	0.47	1.42	0.44	0.01	0.05
Sludge Interstitial Water					
Sample BIW 1	0.64	26.7	4.6	0.33	0.07
Sample BIW 6	0.70	15.6	0.30	0.17	0.09
Sample BIW 14	0.82	0.95	19.3	61.0	<0.01
Sample BIW 22	1.44	0.33	71.3	0.04	0.30
Sample BIW 24	0.26	0.58	190[b]	0.03	0.08

[a] *From A. M. Springer, "Investigation of the Environmental Factors which Affect the Anaerobic Decomposition of Fibrous Sludge Beds on Stream Bottoms" (Ph.D. thesis), Inst. of Paper Chemistry, Lawrence University, Appleton, Wis. 1972.*

[b] *An average of two determinations.*

Table B.21. Trace Metal Concentration of Three Sludge Samples from a Sludge Bed on the Lower Fox River[a]

	Sample SIII	Sample SV	Sample SIX
	All values in percent to ± 5% of value[b]		
Total ovendry solids[c]	17.2	11.2	18.5
Ash (at 550°C)[d]	10.6	3.98	3.84
Magnesium[d]	0.14	0.043	0.048
Calcium[d]	0.18	0.070	0.080
Iron[d]	0.22	0.080	0.066
Aluminum[d]	1.6	0.55	0.48
Silicon[d]	2.2	0.98	0.96
Lead[d]	0.0056	0.0016	0.0014
Zinc[d]	0.36	0.36	0.36
Sodium[d]	0.049	0.018	0.016
Titanium[d]	0.12	0.10	0.094
Copper[d]	0.0022	0.00083	0.0018
Manganese[d]	0.034	0.018	0.013
Potassium[d]	<0.5	<0.18	<0.17

[a]*From A. M. Springer, "Investigation of the Environmental Factors which Affect the Anaerobic Decomposition of Fibrous Sludge Beds on Stream Bottoms" (Ph.D. thesis), Inst. of Paper Chemistry, Lawrence University, Appleton, Wis. 1972.*

[b]*Standard deviation.*

[c]*As percent of total wet weight.*

[d]*As percent of ovendry solids.*

APPENDIX C: BACKGROUND AND HISTORY CONCERNING REGULATION OF LAKE WINNEBAGO

Lake Winnebago is part of the Fox River Navigation Project and regulation of its stage is necessary in the interest of navigation and is required in accordance with Federal laws and to protect the private rights of water-power and riparian interests. The lake is a natural retarding and storage reservoir for water from the Upper Fox River and Wolf River. The lake has a normal low water area of 206 square miles and a surrounding local drainage area of 600 square miles, including 200 square miles of the Fond du Lac River basin at the south end of the lake. The total drainage area above the lake outlets at Neenah and Menasha is 6030 square miles: The Lake Winnebago Pool, which includes six smaller lakes at substantially the same low-water level within the lower parts of the Upper Fox and Wolf River drainage areas, has a total low-water area of 265 square miles. The area of this pool at the highest level of record, with the backwater slopes prevailing, was about 320 square miles. The limits of regulation under existing laws, orders and permits are from 21-1/4 inches above the crest of Menasha dam to the crest level during the navigation season, plus an additional drawdown of 18 to 24 inches during the winter. The storage available in this pool normally is substantially filled during the months of high inflow, thus reducing flood flows of the Lower Fox River; and provides supplemental flow for navigation, water power, water supply and sanitation during the dry months of the year. As the inflow into the Lake Winnebago Pool at flood peaks may be approximately double the safe discharge capacity of the lower river channel, and as during extremely dry periods the evaporation and seepage from the lake may equal or exceed the inflow, the availability of the lake storage and its proper utilization by regulation of the outflow is of major importance to navigation, as well as to the cities and industries along the Lower Fox River utilizing the water supply of the river. In the interest of navigation on the Lower Fox River, to preserve the private rights to the use of water not needed for navigation for power development, and to reduce flood damages, the water level of the Lake Winnebago Pool is regulated to the extent possible in accordance with Acts of Congress and related directives.

The original dam at Menasha was completed in 1850 and the original dam at Neenah was completed in 1854. The deed of transfer of the Fox River Improvements from the Green Bay and Mississippi Canal Company to the United States is dated September 18, 1872, and gives the United States title to all "locks, dams, canals, and franchises savings and excepting therefrom and reserving" to the Green Bay & Mississippi Canal Company "water power created by the dams and by the use of surplus water not required for the purpose of navigation, with the rights of protection and preservation appurtenant thereto, and the lots, pieces, or parcels of land necessary to the enjoyment of the same, and those acquired with reference to the same, all subject to the right to use the water for all purposes of navigation." Later the Congressional Acts of 2 August 1882 and 5 July 1884 provided that the waters of Lake Winnebago shall be

reduced to and maintained at their natural height. The laws do not prescribe exact limits or methods for regulation, but such limits are fixed indirectly by the words "natural and established heights without interfering with private rights."*

The initial construction of dams in the Neenah and Menasha outlet channels by the State and succeeding private corporations affected both the low water level and average high water level of Lake Winnebago and flowage damages were caused which were not paid by the agencies. After the United States took possession of the navigation project works flowage damages amounting to $592,375.09 were paid under authorization by a Congressional Act of 3 March 1875 which provided that payments be made for any lands or property which are "now or shall be flowed or injured" by any of the works of improvement on the Fox River. Funds were provided under six appropriation acts and payments were made during the 1886 to 1896 decade. As far as is known no surveys were made to establish the limits to which payments were made, but statements by persons directly connected with the matter indicate that the settlements covered all lands damaged by flowage around Lake Winnebago, up the Fox River to above Omro or to Eureka Lock, and up the Wolf River through the marshlands above Lake Poygan and Boom Cut. The form of judgment rendered in all cases contained the clause "which damages are assessed from and after the 18th day of September, 1872, and for all time thereafter and allowing the United States to perpetually maintain the dam (at Menasha) mentioned in the petition filed herein at its present height."

The Marshall Order, dated 9 October 1886, was issued shortly after the appropriation act of 4 August 1886, which was the first act in connection with damages.

The following paragraphs are quoted from H. D. No. 146-67th Congress, 2nd session entitled "Fox River, Wisconsin." In order to define more definitely the upper limit of flowage rights acquired by the United States, Capt. W. L. Marshall, then district engineer in charge, wrote to C. A. Fuller, assistant engineer in local charge of the Fox River improvement on October 9, 1886, as follows:

> "The sluiceways in the Menasha Dam are placed by the Government to prevent damage by floods on Lake Winnebago. The term "flood" is to be considered to refer to all stages of water above ordinary high-water stage. The ordinary high-water stage for the past 28 years (1859-1886) as shown by the readings

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**The height of Menasha Dam is the same now as it was when the flowage damages were paid, <u>but it has been lengthened and sluices have been added increasing the discharge capacity about 60 percent</u>. The dam at Menasha was partially rebuilt in 1937 to comply with provisions of the River and Harbor Act of 2 August 1882 which required alterations to the Menasha Dam and channel "not inconsistent with security to navigation, ...to reduce and to maintain the water of Lake Winnegage ...at their natural height." The laws do not prescribe exact limits or methods for regulation, but such limits are fixed indirectly by the words "natural and established heights without interfering with private rights."*

> of Deuchman's gauge at the foot of lake Winnebago, rejecting 1860 when the stage was abnormally low, and 1881, when the water was excessively high. This mean annual high water for 28 years equals 42 inches on Deuchman's gauge, or 3 feet 6 inches. You will therefore begin to open the sluiceways in the Menasha Dam when the water approaches within 2 inches of this height, or at 3 feet 4 inches on Deuchman's gauge, and, as far as the capacity of the Fox River below Menasha and the security of Government works will allow, you will maintain the level of Lake Winnebago at or below the ordinary high-water level of 3 feet 6 inches on the Deuchman gauge by opening and closing the sluiceways in the Menasha Dam."

This long-standing order is commonly known as the Marshall Order. The 3 feet 6 inches upper limit specified is 21-1/4 inches above the crest of Menasha Dam. Adoption of average high water for the years 1859-1886 as the upper limit of regulation was not exceeding the flowage rights acquired by the United States, but, on the contrary, was some concession to riparian interests. As nearly as can be determined by computations based on available data, the limit specified in the order was about the natural flood height before dams were built at Menasha and Neenah and before these natural outlets were widened and deepened. As this limit was established in 1886, it is considered as the established height prescribed by the act of 1896, as well as the natural height provided for by the act of 1882, which latter act was passed immediately following the severe flood in the late fall of 1881. Observance of this upper limit, without unnecessary waste of water, gives water-power interests on the lower river all the water to which they are entitled under the laws and the deed of transfer to the United States without interfering with private rights.

Under authority of River and Harbor Act of 1894 the Secretary of War on 5 February 1895 issued rules and regulations for navigation on Fox River, which includes the regulation that no pool shall be lowered below the crest of the dam which retains that pool. This therefore plainly defines the lower dividing line between the rights of navigation and those of water power.

The River and Harbor of 1896 directed the Secretary of War, by use of flashboards or otherwise, to make avail of all the natural flow of water, and present waste thereof, to the height to which the right of the United States to hold the same has been established and without interfering with private rights. The use of flashboards 8 inches high was permitted from 1899 to 1906, but the permit was revoked 17 July 1906 because the use of flashboards was considered as interference with private rights and therefore illegal.

The Marshall Order was modified in 1920 by Colonel Judson. In this connection the following paragraphs are quoted from H. D. No. 146-67th Congress, 2nd session.

> "On account of repeated objections made by riparian interests to the 19-inch sluicing point specified in the old order of October 9, 1886, and because that portion of the

order has been practically obsolete for many years, the following modified order was issued October 15, 1920, by Col. W. V. Judson, district engineer, to Earl M. Nisen, assistant engineer in charge of the regulation of this lake and to others concerned;

Existing instructions for the regulation of Lake Winnebago, originally adopted by the district engineer on October 9, 1886, as modified June 25, 1920 are hereby further modified so that they shall read as follows:

"(1) The sluiceways in the Menasha Dam are placed by the Government to prevent damage by floods in Lake Winnebago. The term 'flood' is to be considered to refer to all stages of water above an ordinary high-water stage. The ordinary high-water stage will be taken as the mean high-water stage for the 28-year period from 1859 to 1886, as shown by the readings of Deuchman's gauge at the foot of Lake Winnebago, rejecting 1860 when the stage of water was abnormally low and 1884 when the water was excessively high. This mean annual high water for those 28 years is 42 inches on Deuchman's gauge, or 21-1/4 inches above the crest of Menasha Dam.

"(2) The manipulation of the sluices shall, as far as practicable, be such that, with minimum waste of water, high water shall not exceed 21-1/4 inches above the crest of Menasha Dam.

"(3) A continuous hydrograph shall be kept which will serve to indicate at all times what success is being had in complying with paragraph 2 of this order and whether modifications in the details of manipulation are necessary in or to bring about a more perfect compliance with it.

"(4) The Federal laws relating especially to the regulation of Lake Winnebago are as follows: Acts approved August 2, 1882; July 5, 1884; August 18, 1894; and June 3, 1896."

Accordingly the present limits of regulation for Lake Winnebago under existing laws, orders, rules, and permits are from 21-1/4 inches above the crest of Menasha Dam down to the crest during the navigation season, plus an additional 18 inches below the crest during the winter."

Later under authority of Section 7 of the River and Harbor Act of 8 August 1912, the Secretary of the Army on 17 July 1968 approved navigation regulations for the Fox River, rule 13 of which provides that water shall not be drawn from any pool to such extent as to lower the surface of the pool below the crest of the dam which retains that pool. As this rule applies at Menasha Dam it limits the draft of water from Lake Winnebago to the level of the crest of the dam during the navigation season. The Secretary of the Army has regularly issued annual permits to the Neenah and Menasha Water Power Company to draw the lake down not to exceed 18 to 24 inches below the crest of Menasha Dam during

the closed season of navigation, with the proviso that the water level shall be back to the crest of the dam upon the opening of navigation each spring. These permits allow the water-power interests to use all surplus water not needed for navigation to which they are entitled under the existing project. The limits within which the lake level has been regulated since 1950 are shown in Table C.1.

Records of the lake level available from 1859 to date show that since the issuance of the Marshall Order in 1886 the level of the lake generally has been regulated within the specified limits, the upper limit being exceeded in only 15 cases and then usually by only a few inches for a short period, the maximum excess being about 10-1/2 inches in 1960 after a period of unusually large inflow. Several of these high water stages were in April at a season when the overflow of the low lands does little damage by flooding pasture and cultivated lands, hay marshes or forested lands. Damage to lakeshore resort and recreational areas also is relatively small since most summer homes or cottages are built in anticipation of occasional high water. Ice breakups and windblown ice jams may cause considerable shoreline damage if the lake stage is exceptionally high. Conservation interests have observed there is extensive damage to wildlife in the form of nesting ducks, muskrats, etc., when excessively high flood levels occur. Fish spawning beds may be left dry when flood waters recede. Considerable damage also occurs by the loosening and displacement of some areas of floating bog and deposition of the resulting debris in the lake waters. The sluicing capacity at Menasha and Neenah Dams, and at all the other Lower Fox River dams, has been substantially increased since the limits of regulation for Lake Winnebago were established, making it possible to prevent more frequent flooding above the desired limit.

The report in House Document No. 146, 67th Congress, 2nd session, included the findings of a detailed study of the backwater effects of the Lake Winnebago stage. It is shown that with regulation of the lake within ordinary limits the backwater effect above the mouth of the Wolf River due to the higher lake level is only about 0.5 foot and decreases upstream with no backwater effect above Fremont due to the Lake Winnebago stage. The land flooded when the lake level is at the upper limit for regulation 21-1/4 inches above the crest of Menasha Dam outside of the pool area with lake level at the crest of the dam is estimated to be about 13,760 acres. The flooded area probably would be increased about 650 acres at the peak stage of 26.2 inches above the crest reached during the extended high water period in 1960. Most of the flooded area is marshy bottom land.

Major factors affecting lake regulation and flood control are substantially the same now as they were in 1922 when the results of this study were published with the following principal exceptions. The urban and industrial

Table C.1. Extreme Annual Levels of Lake Winnebago, 1950-1975

	Minimum Level			Maximum Level		
Year	Date	Oshkosh Gage, ft.	In. below Crest Menasha Dam	Date	Oshkosh Gage, ft.	In. above Crest Menasha Dam
1950	Mar. 5-6-9	0.50	14.2	Apr. 30 May 4	3.31	19.5
1951	Feb. 24	0.46	14.6	Apr. 26	3.48	21.6
1952	Mar. 18	0.69	11.9	Apr. 13 Apr. 15	3.42	20.9
1953	Mar. 11-13	0.82	10.3	May 5-7-8-10	3.29	19.3
1954	Mar. 12-13	0.71	11.6	Oct. 4	3.35	20.0
1955	Feb. 19	0.98	8.4	June 11	3.25	18.8
1956	Mar. 31	0.78	10.8	May 10 May 30	3.30	19.4
1957	Mar. 17	0.79	10.7	June 5	3.30	19.4
1958	Feb. 28 Mar. 3	0.91	9.2	July 15	2.54	10.3
1959	Mar. 30	0.78	10.8	May 29	3.38	20.4
1960	Mar. 28	1.12	6.7	May 17	4.32	31.7[a]
1961	Feb. 17	1.32	4.3	Oct. 29	3.35	20.0
1962	Mar. 20	0.80	10.6	June 18	3.20	18.2
1963	Mar. 22	1.03	7.8	May 29	2.98	15.6
1964	Mar. 6-8	1.19	5.9	May 25	3.18	18.0
1965	Mar. 1	1.23	5.4	Apr. 29	3.23	18.6
1966	Feb. 7	1.49	2.3	May 27	3.00	15.8
1967	Mar. 17	0.77	10.9	May 19	3.22	18.5
1968	Mar. 17-18	1.28	4.8	Aug. 7	3.42	20.9
1969	Mar. 17	0.97	8.5	June 29	3.86	26.2[b]
1970	Mar. 19	1.06	7.5	June 3	3.22	18.5
1971	Mar. 13-14	1.01	8.06	June 13	3.30	19.37
1972	Mar. 19-20	.94	8.87	June 3	3.23	8.62
1973	Mar. 5	1.35	4.00	May 19	3.68	24.00
1974	Mar. 2-3	0.84	10.12	June 18	3.37	20.25
1975	Mar. 19-20	0.70	11.75	May 6	3.30	19.37

[a] *Total of 32 days above 3.45 feet at Oshkosh gage, or more than 21-1/4 inches above crest.*

[b] *Total of 21 days above 3.45 feet at Oshkosh gage, or more than 21-1/4 inches above crest.*

developments along the Lower Fox River and the shores of Lake Winnebago have been greatly expanded. The residential developments along the shores of the Lake Winnebago Pool has greatly expanded, so that many sections subject to flooding now are used for residential purposes. The sluicing capacity at all dams on the Lower Fox River has been increased so that the outflow from Lake Winnebago can be increased from about 15,000 cfs to 20,000 cfs without serious flood damages along the Lower Fox River. However, the large excess of inflow over outflow at times still makes it physically impossible to regulate the lake level below the prescribed flood limit and still avoid excessive waste of water to which water-power interests have established legal rights. Flowage damages amounting to $592,375.09 were paid by the United States through the courts under special appropriation acts in 1886 to 1894. The dam is still at the same height as when the flowage damages were awarded but has been lengthened and sluices have been added. Most of the damages resulting in the few instances when the level of the pool cannot be kept below the 21-1/4 inch limit are within the area for which these flowage damages were paid, to properties developed with insufficient regard for the flood hazard, and consequently the Federal government is not liable to the owners.

APPENDIX D. UPRIVER LAKES HABITAT

Table D.1. Wetland Acreage--Fox and Wolf Rivers--
Lakes Area, Waushara County, Wisconsin

Wetland Classification	Year 1937	1957	1971
Pothole	4	--	16
Fresh meadow	7,822	7,022	5,681
Shallow marsh	1,975	2,356	3,404
Deep marsh	79	111	50
Shrub swamp	241	182	149
Timber swamp	4,591	4,278	4,184
Total	14,712	13,949	13,484

Percentage Wetland Losses

1937 - 1957 = 763 (5%)

1937 - 1971 = 1,228 (8%)

1957 - 1971 = 465 (3%)

Table D.2. Wetland Acreage--Fox and Wolf Rivers--
Lakes Area, Waupaca County, Wisconsin

Wetland Classification	Year 1937	1957	1971
Pothole	--	--	21
Fresh meadow	1,669	1,405	972
Shallow marsh	1,793	1,547	1,152
Deep marsh	669	775	582
Shrub swamp	33	22	279
Timber swamp	1,140	1,082	1,047
Total	5,304	4,831	4,053

Percentage Wetland Losses

1937 - 1957 = 473 (9%)

1937 - 1971 = 1,251 (24%)

1957 - 1971 = 778 (16%)

Table D.3. Wetland Acreage--Fox and Wolf Rivers--
Lakes Area, Winnebago County, Wisconsin

Wetland Classification	Year 1937	1957	1971
Pothole	8	1	70
Fresh meadow	12,824	6,114	4,422
Shallow marsh	10,768	9,008	7,334
Deep marsh	3,488	1,793	1,575
Shrub swamp	1,131	1,090	1,080
Timber swamp	2,845	2,182	1,744
Total	31,064	20,190	16,225

Percentage Wetland Losses

1937 - 1957 = 10,874 (35%)

1937 - 1971 = 14,839 (48%)

1957 - 1971 = 3,965 (20%)

Table D.4. Lake Surface Acreage Summary, Fox and
Wolf Rivers-Lakes Area, Wisconsin

Lakes	Year 1937	1957	1971
Partridge	574	553	554
Poygan	13,178	13,646	14,198
Winneconne	5,214	5,399	5,616
Buttes des Morts	6,743	7,151	7,160
Total	25,709	26,749	27,528

D-3

RETYPED FOR THIS REPORT.

STATE OF WISCONSIN

CONSERVATION DEPARTMENT

Madison
August 20, 1958

Col. J. B. W. Corey, Jr.
U.S. Army Corps of Engineers
Chicago District
475 Merchandise Mart
Chicago 54, Illinois

Dear Colonel Corey:

This is in acknowledgment of your letter of August 7 regarding the levels of Lake Winnebago and the proposal to open the lake to navigation at an earlier date than has been done previously. We appreciate your consideration of our request in this matter.

We do feel that an earlier opening date could accomplish what we wish in the way of higher water levels in early spring which we feel will be beneficial to fish life and also to early commercial fishing navigation.

We appreciate very much your cooperation with us in this as well as other matters, and hope that we can reciprocate in the same manner in any problems that would involve us.

Very truly yours,
/s/ L. P. Voigt
L. P. Voigt
Conservation Director

RETYPED FOR THIS REPORT

7 Aug 1958

Mr. L. P. Voigt
Conservation Director
State of Wisconsin Conservation Department
State Building
Madison, Wisconsin

Dear Mr. Voigt:

The discussion held in your office relative to the regulation of Lake Winnebago, Wisconsin on 30 July 1958 among representatives of your Department, water power interests and my office has been brought to my attention.

Your desire to have the level of Lake Winnebago at or above the crest of Menasha Dam earlier in the spring in order to mininize fish kill and aid commercial fishing interests in the bayous of the Wolf River, Partridge Lake and the bays of Lake Butte des Morts is fully appreciated. As you know it is necessary that the water level of Lake Winnebago be at or above the crest of Menasha Dam on the opening date of navigation and not fall below that elevation during the navigation season.

It has been determined that the opening of navigation will continue to be influenced by commercial navigation on the lower Fox River. However, on an experimental basis, if feasible and starting in 1959, the level of Lake Winnebago will be at or above the crest of Menasha Dam on or before 5 April. It is understood that no objection to this plan of operation was voiced by the water power interests in attendance at the meeting on 30 July.. In order for them to know of this modification in the regulations copies of this letter are furnished those interests.

This office regulates Lake Winnebago in accordance with existing laws and attempt to satisfy many varied interests. I hope that the recent proposed modification will be to your satisfaction. If you have any additional suggestions in this matter, I would be pleased to hear from you.

Sincerely yours,

J. B. W. CONEY, JR.
Colonel, Corps of Engineers
District Engineer

Copy to:
Orbison & Orbison
Neenah and Menasha
Water Power Co.

D-5

RETYPED FOR THIS REPORT

2 August 1958

MEMORANDUM FOR: FILES

SUBJECT: Regulation of Lake Winnebago, Wisconsin

1. A conference was held in the office of the Wisconsin Conservation Department, State Office Bldg., Madison, Wis., at 11 a.m. on 30 July 1958 relative to the regulation of Lake Winnebago, Wis. Those in attendance were as follows:

L. S. Voigt, Conservation Director, Wisconsin Conservation Dept.

George Sprecher, Asst. Conservation Director, Wisconsin Conservation Dept.

Cy Kubat, Research Coordinator, Wisconsin Conservation Dept.

Jno.Ockerman, Engineer, Wisconsin Conservation Dept.

Richard Harris, Wisconsin Conservation Dept.,Oshkosh

George P. Steinmetz, Wisconsin State Engineer and Commissioner, Wisconsin Public Service Commission

Roy C. Tulane, Attorney, Attorney General's Office

Thomas Orbison, Consulting Engineer, Appleton

Harold Jones, Kimberly Clark Corp., Neenah

G. B. Wesler, Corps of Engineers, Chicago District.

2. The conference was held in response to request in letter from Mr. Voigt dated 16 June 1958. Mr. Harris reiterated the contents of that letter stating that low water in the bayou of the Wolf River, Partridge Lake and the bays of Lake Butte des Morts in the late winter and early spring caused fish kill and navigational difficulties for commercial fishermen. He believed that the same consideration sould be given those interests in selecting the date for opening of navigation as has been given to the commercial navigation interests on the lower Fox River. The representatives of the Conservation Dept. would appreciate it if an earlier date for opening of navigation is selected so that the level of Lake Winnebago would be at the crest of Menasha Dam earlier in April.

3. The Corps of Engineers' representatives outlined the basic laws and instructions for the regulation of Lake Winnebago. He presented a table showing the gage elevations.at Oshkosh for the past 20 years and also hydrographs of the lake level and Berlin and New London gages. He

RETYPED FOR THIS REPORT

NCWOW 2 August 1958
SUBJECT: Regulation of Lake Winnebago, Wisconsin

stated that there would be no objection from the Corps of Engineers if the level of Lake Winnebago was at the crest of Menasha dam slightly earlier in the spring provided water conditions warranted it and there was no objection from the power interests, who are entitled to all water surplus to the needs of navigation.

4. The water power interests stated that the regulation of Lake Winnebago in recent years was entirely to their satisfaction and they would voice no objection to the state proposal.

5. Accordingly it was agreed that on an experimental basis the opening date of navigation would continue to be governed by navigation interests on the lower Fox River but the level of Lake Winnebago would be at or above the crest of Menasha Dam by 5 April, if feasible. This meets with the desires of the state representatives.

G. B. WESLER
Chief, Planning and Reports Branch

Dep... ...t of Natural Resources
INTRA-DEPARTMENT
MEMORANDUM

Green Bay
Station

Date April 23, 1976 IN REPLY REFER TO: 3530-7

TO: Floyd Stautz

FROM: S. G. DeBoer

SUBJECT: Water Level Control Lake Winnebago, Winnebago County

Pursuant to M. C. 1462.4., the Lake Michgain District requests your office contact the Army Corps of Engineers and suggest implementation of a modified schedule of operation of the Lake Winnebago pool as follows:

1. Reduce water levels to spillway level by December 31.

   Reason: This will reduce the amount of ice forming in the marshes.

2. Gradually draw down in February to a low in March to make room for spring run-off. Gradual reduction in February would have a minimal impact on ice fishing.

3. The low in March should be at least 1.0 feet below the crest of the Menasha dam in order to provide sufficient storage for spring flows.

   Reason: Water level rises in April due to spring run-off can then be tapered off to allow submergent vegetation to start growing earlier before peak water levels are attained. This is based on the assumption that light is a limiting factor in deep water which prevents vegetation growths from starting. Once the vegetation has started growing and if the water level rise is gradual, vegetation growth will keep pace with it.

4. Water levels should be up to spillway level by April 30, rather than April 1st., as is the present case.

   Reason: Water levels close to spillway level in April will reduce the detrimental effects of ice action during the break-up period. Lifting action of large masses of ice in the bog areas would therefore not be a factor during the break-up. Ice in the bog would be minimal and should quickly melt out since the black bottom soils, which would be partially exposed, would absorb heat and cause faster melting.

5. Allow gradual rises in water level during May to peak summer level in June.

   Reason: This will allow submergent vegetation growths to keep pace with water level increases. The latter part of

April, May and the first part of June is probably the most important period for plant growth. Sufficient light is essential if plants are to begin growth. Deep turbid water does not provide conditions required for growth. If we can hold water low during the early period in April when plants are very short and just beginning to grow we may obtain a response which will result in increased areas of submergents. By the end of May plants are sufficiently tall so that deep water will no longer be inhibiting factor.

6. After summer water levels peak in June there should be no further rise from June into August if desirable submergents are to have maximum fruit production. A long slow decline in water levels during this period would be desirable.

   Reason: Plants seem to set seeds better under conditions of declining water levels. Wild celery does not flower until the end of July. If the water should suddenly rise at this time celery plants might not be fertilized. Since flowers rise above the surface for pollination, if they were inundated pollination might not occur. Wild rice begins to erect the first part of July and any sudden rise in water levels during this period could tear the plants loose. By the end of August growth is more or less completed for all forms of vegetation and plants are going into senescence.

7. A rise in water levels in September and October brought about by fall rains would provide better conditions for waterfowl hunting and boating.

8. Sudden or abrupt rises in water level should be avoided at all times because of its damaging effect on vegetation. Water levels should decline from the fall high beginning in the latter part of October or the first part of November and be at spillway level by December 31.

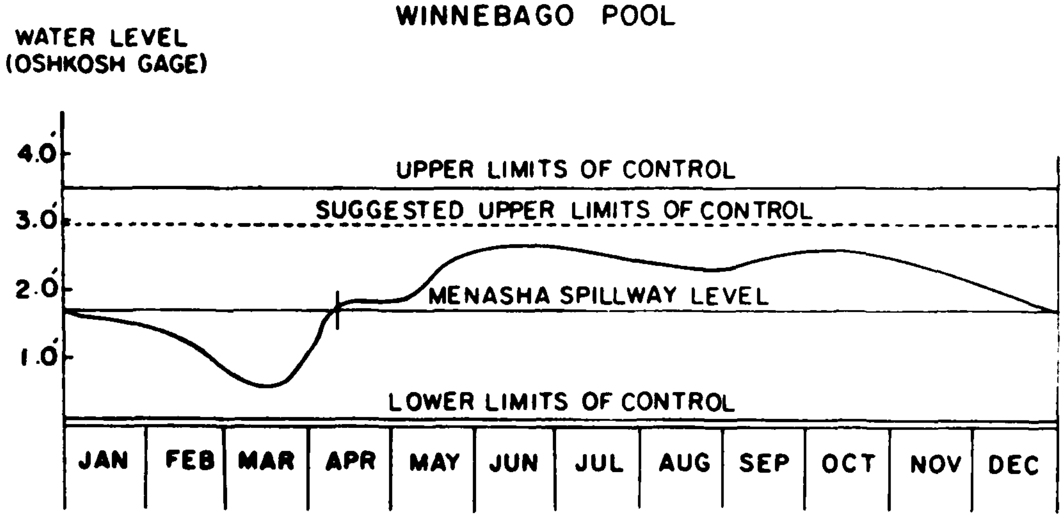
S. G. DeBoer

cc: Arlyn Linde
Walter Naab
Ross Plainse
John Weber

NOTED:

__________ Date

SUGGESTED WATER LEVEL REGIME FOR WINNEBAGO POOL



APPENDIX E: SOILS AND GEOLOGY

The various soil types in the project study area are described below. Figure E.1 provides a graphic presentation of these general soil associations.

Kewaunee Series - The Kewaunee series consists of deep, nearly level to very steep, well-drained soils on uplands. These soils developed in a thin silt mantle and calcareous, fine-textured, reddish-brown glacial till. The original vegetation was hardwoods.

In a representative profile the surface layer is very dark gray silt loam about three inches thick. The subsurface layer is grayish-brown silt loam four inches thick. The subsoil extends to a depth of about 28 inches. It is reddish-brown silty clay loam in the upper three inches and dark reddish-brown and reddish-brown clay in the lower part. The lower part of the subsoil is neutral to mildy alkaline. The underlying material is reddish brown clay to a depth of 36 inches and silty clay below. Spots of lime occur in this layer.

Permeability is moderately slow in the subsoil and slow in the underlying material. The available water capacity is high. The subsoil is medium acid to mildy alkaline. These soils are moderately fertile. The organic-matter content of the surface layer is medium.

Kewaunee soils are important to the economy of the county. With related soils, they occupy a 2- to 6-mile-wide strip of land adjacent to Lake Winnebago. Nearly all the acreage has been cleared and is used for crops. These soils are easily puddled if they are worked or grazed when too wet.

Houghton Series - The Houghton series consists of organic soils that formed in the remains of such fibrous plants as grasses, sedges, reeds, and other nonwoody plants. These soils occupy small depressions a few acres in size or entire valley bottoms that cover several hundred acres.

In a representative profile the surface layer is black mucky peat 16 inches thick. Below this, to a depth of about 60 inches, is dark reddish-brown and dark-brown distintegrated and finely divided sedge peat.

The Houghton soils are neutral to mildly alkaline. The available water capacity is very high, and the water table is high. Natural fertility is moderately low.

Soils of the Houghton series, the most extensive of the organic soils in this region, occur throughout the area. They are primarily under a cover of native vegetation. Some areas are used for permanent pasture, but scattered areas have been drained and are used for crops. These soils are subject to ponding. Where they have been drained, subsidence and soil blowing are serious hazards. Many areas that are not cropped at present represent an important farm potential.

Oshkosh Series - The Oshkosh series consists of deep, nearly level and gently sloping, moderately well-drained and well-drained soils. These soils formed in a very shallow silt mantle and calcareous, fine-textured, lake-laid sediments that are reddish brown in color. The original vegetation was hardwood forest.

In a representative profile the surface layer is very dark grayish-brown silt loam seven inches thick. The subsurface layer is grayish-brown silt loam five inches thick. The subsoil is dark-brown, dark reddish-brown, and reddish-brown silty clay and clay about 13 inches thick. The underlying material is moderately alkaline, reddish-brown clay.

Oshkosh soils have high available water capacity and are moderately fertile. Permeability is moderately slow in the subsoil and slow in the substratum. These soils are neutral to moderately alkaline.

Manawa Series - The Manawa series consists of deep, nearly level and gently sloping, somewhat poorly drained soils on uplands. These soils developed in a thin silt mantle and calcareous, fine-textured, reddish-brown glacial till or lacustrine sediments. They are adjacent to wetlands, shallow drainageways, and small depressions. The original vegetation was hardwood forest.

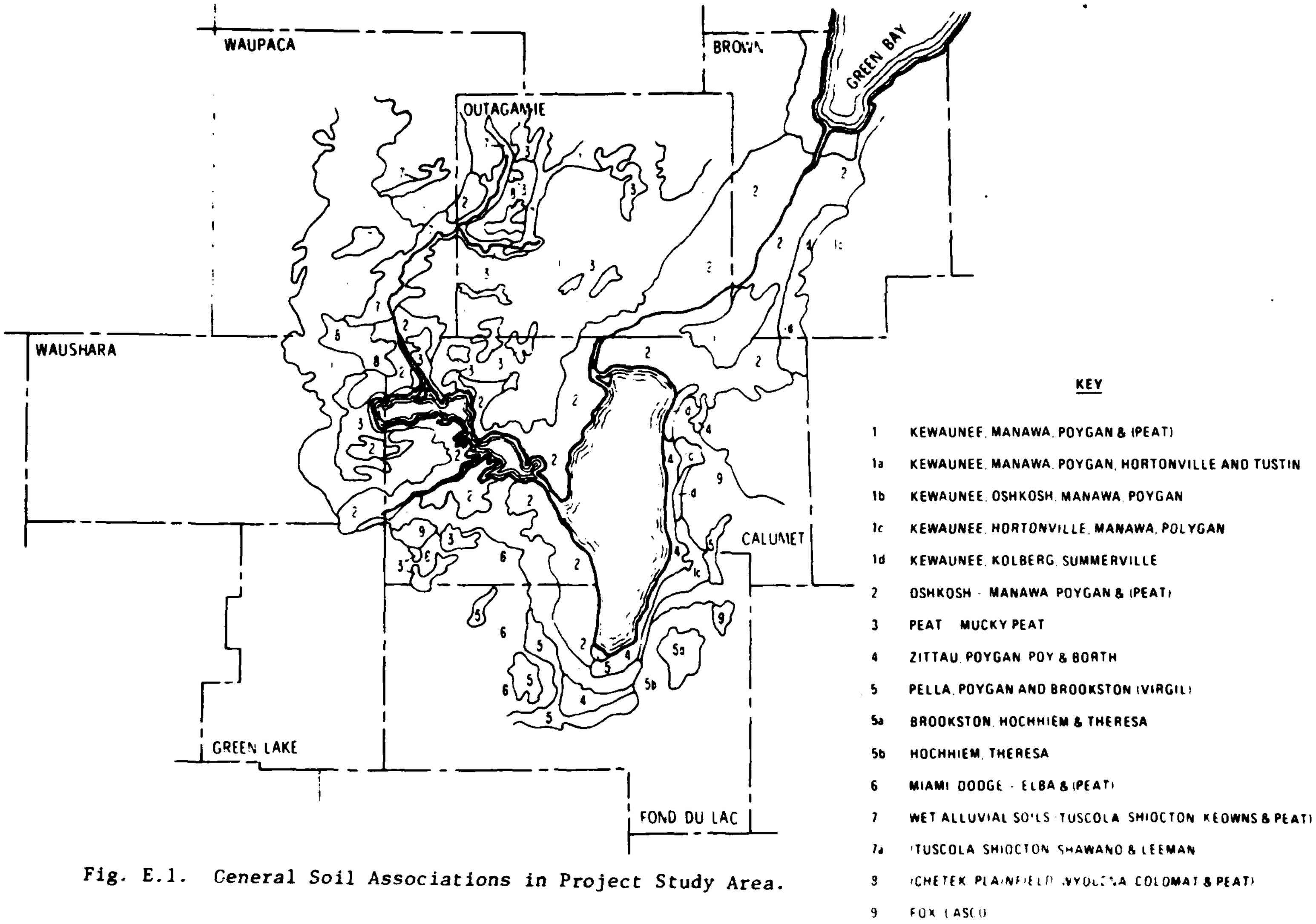


Fig. E.1. *General Soil Associations in Project Study Area.*

In a representative profile the surface layer is black silt loam five inches thick. The subsurface layer is dark-gray silt loam four inches thick. The subsoil is mottled, reddish-brown silty clay that extends to a depth of 28 inches. The underlying material is reddish-brown silty clay that contains segregated lime between the cleavage planes.

Manawa soils have nigh available water capacity. They are moderately slowly permeable in the subsoil and slowly permeable in the substratum. The surface layer is neutral, the subsoil is slighly acid to neutral, and the substratum is alkaline. These soils are moderately fertile, and the surface layer is medium in organic-matter content.

Manawa soils are important, especially in the Lake Winnebago Valley. They occur in a 2- to 6-mile-wide strip adjacent to the lake. Most areas have been cleared and are used for crops, but a few areas are in woodlots or wooded pasture. Wetness is the main limitation to farming. These soils are easily puddled if worked or grazed when wet.

Manawa silty clay loam, 0 to 2 percent slopes - This soil occupies shallow drainageways, small depressions, and areas adjacent to wetlands. The surface layer generally is less than nine inches thick, and the combined surface layer and subsoil is less than 24 inches thick. The surface layer has a higher percentage of clay than that of the representative profile. This is a result of mixing some of the clayey subsoil material with the surface layer through tillage.

This soil occupies a position on the landscape between the gently sloping Kewaunee soils and the poorly drained Polygan soils. Small areas of associated Kewaunee and Oshkosh soils were included in mapping.

The infiltration rate is slow, and water is held in the upper part of the soil in spring and during extremely wet periods.

Manawa silty clay loam, 2 to 6 percent slopes - This soil occupies drainageways that dissect Kewaunee soils as well as broad areas adjacent to the poorly drained Poygan soils. The surface layer generally is less than nine inches thick and the combined surface layer and subsoil is less than 24 inches thick. The texture of the surface layer is a result of mixing the original surface layer with some of the subsoil through tillage. Small areas of eroded Manawa soils were included in mapping.

Manawa silt loam, 0 to 2 percent slopes - This soil occupies shallow drainageways and small depressions adjacent to wetlands. It has the profile described as representative to the series. This soil is generally between the gentlv sloping Kewaunee soils and the poorly drained Poygan soils. Areas of associated Oshkosh and Kewaunee soils were included with this soil.

The main limitation to use of this soil is excessive wetness. The infiltration rate is slow, and in spring or during rainy seasons, water is held in the upper part of the soil.

Manawa silt loam, 2 to 6 percent slopes - This soil occupies drainageways that dissect the well-drained Kewaunee soils and slopes adjacent to wide areas of poorlv drained Poygan soils. The surface layer is 7 to 10 inches thick, and the underlying glacial till is generally at a depth of less than 24 inches. The mottling in the upper part of the subsoil is somewhat less conspicuous than that in the representative profile. Small areas of eroded Manawa silt loam were included in mapping.

Excessive wetness is the main limitation to use of this soil. The rate of infiltration is slow, and water is held in the upper part of the soil in spring and after heavy rains. Runoff from adjoining slopes adds to the wetness.

<u>Poygan Series</u> - The Poygan series consists of deep, nearly level to gently sloping, poorly drained soils on uplands. These soils developed in very shallow silt over calcareous, fine-textured, reddish-brown glacial till or lacustrine sediments. The soils that formed in sediments occupy wide areas of lacustrine material; those that formed in glacial till occupy broad depressions and a few drainageways and seepage spots. The original vegetation was water-tolerant trees, shrubs, and grass.

In a representative profile the surface layer is black silty clay loam seven inches thick. The subsoil extends to a depth of 27 inches. It is gray and very dark gray silty clay and clay in the upper part and reddish-brown clay in the lower part. The underlying material is reddish-brown silty clay.

Poygan soils have high available water capacity. They are slowly permeable and mildly alkaline in the surface layer and subsoil. Natural fertility is high, and the organic-matter content of the surface layer is high.

These soils occur extensively in the red clay area of the Lake Winnebago Valley. They are used mostly for crops. Drained areas are suited to all crops commonly grown on dairy farms; in undrained areas alfalfa winterkills and other crops often drown out after heavy rains. Wetness is the main limitation to use of these soils, but it is also difficult to maintain good tilth. These soils puddle if worked or grazed when wet.

Poygan silty clay loam, 0 to 2 percent slopes - This soil occupies wide depressions and, in some places, nearly level wet drainageways. It has the profile described as representative of the series. In most areas this soil has been plowed, and the original surface layer has been mixed with some of the silty clay subsoil.

This soil is associated with the well-drained Kewaunee soils, the moderately well-drained to well-drained Oshkosh soils, the moderately well-drained Peebles soils, and the somewhat poorly drained Manawa soils. Small areas of Manawa silt loam and silty clay loam were included in mapping. Also included were small areas of Poygan soil where the surface layer is silt loam.

Except for alfalfa, this soil is suited to all crops generally grown in a dairy farming area. Excessive wetness is the main limitation to use of this soil. Water moves through the soil rather slowly and results in the formation of a perched water table, especially in spring and after heavy rains. The surface layer tends to puddle after rains and then dries into hard clods that make the preparation of a good seedbed difficult.

Marsh - Marsh consists of wet, periodically flooded areas covered mainly by sedges, cattails, rushes, and water-tolerant trees. Marsh areas that lie adjacent to lakes or ponds are mainly organic or a mixture of organic and mineral material. Other areas of Marsh occur along streams. They consist of alluvial material that is covered by water most of the year.

Where Marsh consists of organic material, it has a black to very dark brown surface layer. Seams or layers of marl are common. This material has very high available water capacity and is low in natural fertility. It ranges from neutral to moderately alkaline. Where alluvial marshes consist of mineral soil, they have a black to very dark brown surface layer and a dark-gray subsurface layer. This kind of marsh is moderately fertile and has high available water capacity. It is neutral to moderately alkaline.

The largest acreage of Marsh is adjacent to Lake Winnebago. This land type is suited to wildlife habitat. It is not suited to cultivation and provides very poor pasture. Drainage generally is not feasible.

Rimer Series - The Rimer series consists of deep, somewhat poorly drained soils in shallow drainageways and small depressions. These soils formed in sandy lacustrine sediments underlain by calcareous, fine-textured, reddish glacial till. The original vegetation was hardwood forest.

In a representative profile the surface layer is very dark gray loam 10 inches thick. The subsurface layer is yellowish-brown fine sandy loam and grayish-brown fine sand 12 inches thick. The subsoil is reddish-brown silty clay about eight inches thick, and the underlying material is reddish-brown silty clay.

Rimer soils have high available water capacity in the rooting zone to a depth of 60 inches. Permeability is moderate to rapid in the surface layer and moderately slow in the subsoil and substratum. These soils are neutral to moderately alkaline. The surface layer is medium in organic-matter content.

Rimer soils are generally within two miles of Lake Winnebago. They are used mainly for crops. Wetness and the moderately slow permeability of the lower part of the subsoil are the principal limitations to use.

Allendale Series - The Allendale series consists of deep, somewhat poorly drained soils on lacustrine plains. These soils formed in sand and in the underlying clayey lacustrine sediment or glacial till. Slopes range from 0 to 3 percent.

In a representative profile the surface layer is dark grayish-brown loamy fine sand about eight inches thick. The subsurface layer, about seven inches thick, is reddish-yellow and strong-brown fine sand mottled with yellowish red and light brownish gray. The subsoil is about 25 inches thick. It is dark-brown to brown fine sand mottled with reddish-yellow in the upper part, brown loamy fine sand mottled with reddish-yellow and gray in the middle part, and reddish-brown silty clay mottled with strong brown and reddish-yellow in the lower part. The substratum is reddish-brown silty clay that extends to a depth of 60 inches.

Allendale soils have medium available water capacity. The sandy part of the profile is rapidly permeable, and the clayey lower part and the substratum is slowly permeable. In wet seasons water remains above the slowly permeable substratum. Reaction is neutral to moderately alkaline.

Pella Series - The Pella series consists of deep, nearly level, poorly drained soils that developed in silt. In most places these soils are underlain by calcareous loam glacial till, and they occupy depressions and valleys in the uplands. In some places Pella soils are underlain by fine-textured lacustrine sediments and occupy broad plains and valley bottoms. The original vegetation was water-tolerant trees, shrubs, and grasses.

In a representative profile the surface layer is black silt loam 12 inches thick. The subsoil is about 30 inches thick. It is olive-gray and yellowish-brown light silty clay loam and silt loam mottled with brownish-yellow. The underlying material is brown silty clay loam.

Pella soils occur in nearly all townships in Fond du Lac County and are important for farming. Undrained areas of these soils are mainly in permanent pasture or woodland; drained areas are suited to most of the common crops. Wetness is the main limitation to farming these soils. Excess water is at or near the surface during most of the year.

Brookston Series - The Brookston series consists of deep, nearly level and gently sloping, poorly drained soils that developed in moderately deep silt and calcareous loam glacial till. These soils occupy depressional areas and drainageways in the uplands.

In a representative profile the surface layer is mildly alkaline, black silt loam about 12 inches thick. The subsurface layer is dark grayish-brown clay loam about two inches thick. It is mottled with yellowish-brown. The subsoil, which extends to a depth of about 30 inches, is mildly alkaline, dark grayish-brown and grayish-brown clay loam mottled with yellowish-brown. The underlying material is olive-gray gravelly loam mottled with yellowish-brown to a depth of about 60 i . It is moderately alkaline.

Brookston soils are moderately slow in permeability, and they have high available water capacity. Wetness is the main limitation to farming. Water may be at or near the surface in spring or after heavy rains.

Tustin Series - The excessive to well-drained, nearly level to sloping soils of the Tustin series have developed in water laid sandy material over calcareous reddish-brown clayey substratum. They occupy old glacial lake basins.

The following profile description of 254-B-1, Tustin sandy loam, 2 to 6 per cent slopes, is representative of the series.

Surface soil - 0 to 10 inches, dark yellowish-brown, loose when dry, single grain sandy loam; 10 to 20 inches, dark brown to brown, loose when dry, single grain loamy fine sand.

Subsoil - 20 to 23 inches, reddish-brown, hard when dry, subangular blocky sandy clay loam; 23 to 34 inches, dark reddish-brown to reddish-brown, firm, subangular blocky silty clay.

Substratum - 34 to 46 inches, reddish-brown, firm, massive, lacustrine silty clay.

Surface textures are sandy loam and loamy sand. Depth to the clayey substratum ranges from 20 to 40 inches.

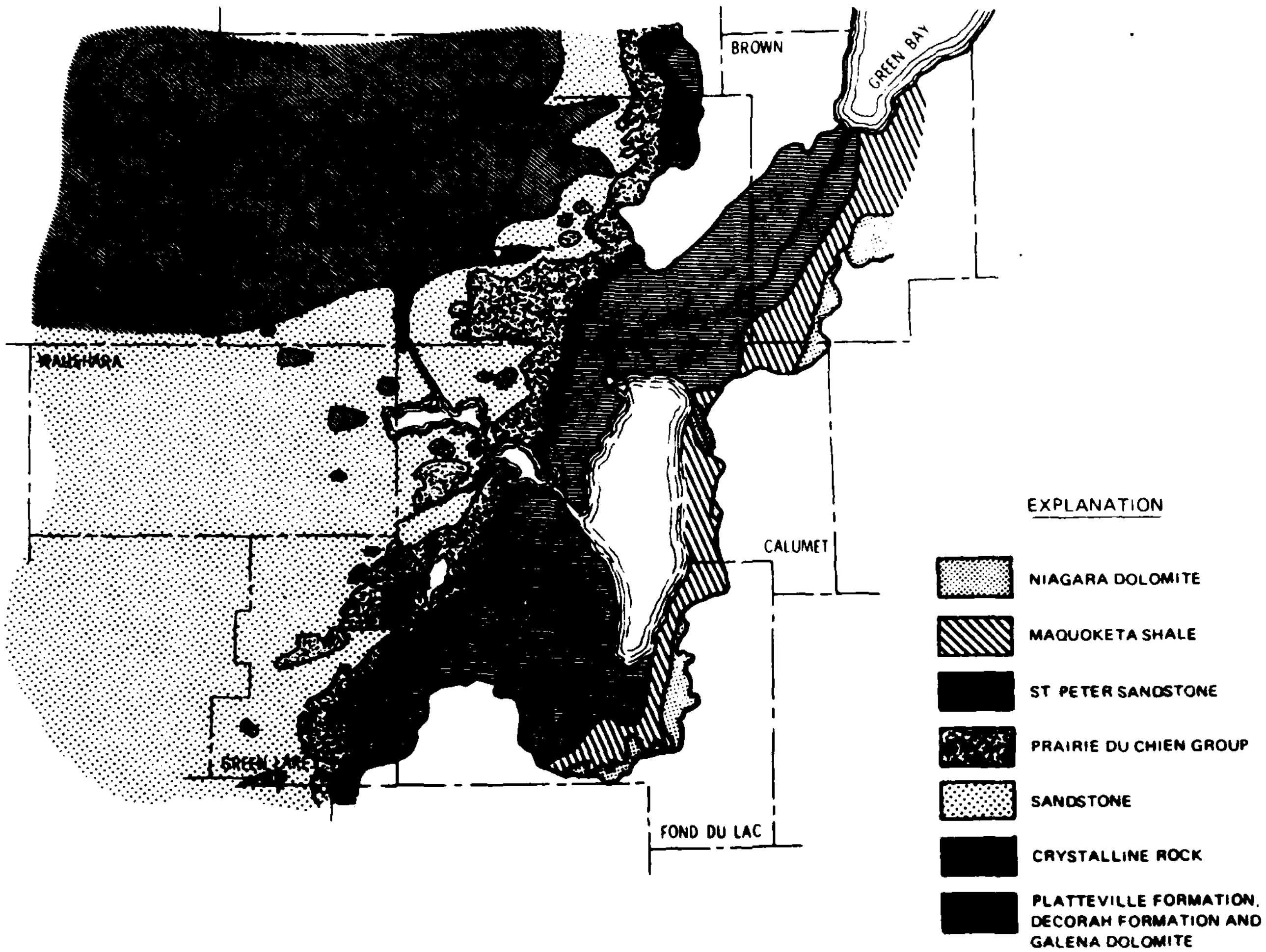


Fig. E.2. Bedrock Geology of the Project Study Area. Modified from P. G. Olcott, "Hydrologic Atlas," 1968.

Table E.1. Generalized Stratigraphic Column of the Wolf-Fox Drainage Basin

System	Rock Unit	Approximate Thickness (feet)	Lithology	Water-Yielding Characteristics
Quaternary	Pleistocene and recent deposits	320	Unstratified till, stratified clay, silt, sand and gravel	Yield 50 pgm or less from sand and gravel layers and lenses depending on thickness and extent. Recent alluvium not considered an aquifer.
Silurian	Niagara dolomite	360	Dolomite - light gray, fine grained, thinly bedded to massive. Some chert.	Yield small quantities of water from joints, bedding planes, and solution channels.
Ordovician	Maquoketa shale	325	Shale - blue-gray, compact. Some thin dolomite beds.	Yields little water. Not considered an aquifer.
	Platteville formation	213	Dolomite - thin to medium bedded. Some chert and shale.	Yield small quantities of water from joints, bedding planes, and solution channels.
	St. Peter sandstone	290	Sandstone - white to pink, fine to medium grained, dolomitic. Poorly cemented in places. Thin beds of red shale are common near base.	Yeilds small to large quantities of water depending on thickness.
	Prairie du Chien group	265	Dolomite - light gray to white, thinly bedded to massive, a few layers of chert, sandstone and shale.	Yields small quantities of water from joints, bedding planes, and solution channels.
Cambrian	Trempealeau formation	120	Sandstone - light gray to pink, fine to medium grained, a few beds of red siltstone and sandy dolomite.	Yield medium to large quantities of water depending on permeability and thickness.
	Franconia sandstone	155	Sandstone - light gray, fine to coarse grained, well cemented, dolomitic, glauconitic.	
	Dresbach group	350	Sandstone - light gray to white, fine to coarse grained, well cemented, hard and with some shale layers.	
Precambrian			Granite - red, pink and gray, and other crystalline rocks. Weathered at top.	Not an aquifer.

APPENDIX F: STREAM DATA

4-0735. Fox River at Berlin, Wis.

Location.--Lat 43°57'15", long 88°57'10", in NE 1/4 sec. 16, T. 17 N., R. 13 E., on left bank, 0.4 mile downstream from government dam, 1 mile south of Huron Street bridge in Berlin, 2 1/2 miles upstream from Barnes Creek, and at mile 89.0.

Drainage area.--1,430 sq mi, approximately.

Gage.--Recording gage. Datum of gage is 744.52 ft above mean tide at New York City (by Corps of Engineers). Prior to Oct. 27, 1954, nonrecording gage at site 0.3 mile upstream at same datum.

Stage-discharge relation.--Defined by current-meter measurements below 5,100 cfs.

Historical.--The flood of Mar. 17-18, 1946, was the highest since 1888 according to the Berlin Journal-Courant. The Corps of Engineers lists the maximum stage as 16.2 ft in 1881.

Remarks.--Only annual maximum daily discharges are shown prior to 1942; daily stages and discharges 1942-49, 1951-55, and momentary peaks 1950, 1956-68. Records computed by Corps of Engineers and reviewed by Geological Survey 1898 to 1939.

Peak stages and discharges

Water year	Date	Gage height (feet)	Ice effect (feet)	Discharge (cfs)
1881		16.2		
1898	Mar. 16, 1898			2,730
1899	Apr. 9,11, 1899			2,800
1900	Apr. 2, 1900			2,830
1901	Mar. 29, 1901			4,800
1902	May 25, 1902			2,450
1903	Mar. 24,25, 1903			2,670
1904	Mar. 27, 1904			5,400
1905	June 10,11, 1905			5,920
1906	Mar. 30, 1906			4,450
1907	Mar.28-31, 1907			2,520
1908	Mar.14,15, 1908			4,020
1909	May 3-6, 1909			2,910
1910	Mar. 17, 1910			3,080
1911	Feb.26,27, 1911			2,600
1912	Mar.31,Apr.1, 1912			4,100
1913	Mar. 31, 1913			4,340
1914	June11,12, 1914			2,750
1915	Mar. 18, 1915			3,000
1916	Mar.28,30, 1916			6,400
1917	Mar. 27, 1917			5,650
1918	Mar.21-23, 1918			6,050
1919	Mar.20-21, 1919			2,670
1920	Mar. 29, 1920			5,150
1921	May 1,2, 1921			2,450
1922	Mar. 16, 1922			5,920
1923	Apr. 12, 1923			6,050
1924	Apr.9,10, 1924			4,020
1925	Mar.23,25, 1925			2,520
1926	Apr.1,2, 1926			3,440
1927	Mar. 12, 1927			3,170
1928	Mar.23,24, 1928			5,920
1929	Mar.21,23, 1929			6,620
1930	Mar. 5, 1930			3,000
1931	Apr.5,8, 1931			1,140
1932	Jan. 23, 1932			1,910
1933	Apr. 11, 1933			2,600
1934	Apr.6-8, 1934			1,910

Water year	Date	Gage height (feet)	Ice effect (feet)	Discharge (cfs)
1935	Mar. 21,22, 1935			4,340
1936	Mar. 27, 1939			4,340
1937	Mar. 20, 1937			3,260
1938	Sept.21-23, 1938			6,190
1939	Mar. 26, 1939			4,910
1940	June 28, 1940			4,720
1941	Apr. 3-6, 1941			3,540
1942	Mar. 20,21, 1942	11.8		2,740
1943	Mar.31,Apr.1, 1943	14.7		5,080
1944	Apr. 28,29, 1944	11.1		2,290
1945	Mar.18,19, 1945	12.8		3,460
1946	Mar.17,18, 1946	15.6		6,900
1947	Apr. 12, 1947	12.2		3,160
1948	Mar. 22, 1948	13.7		4,540
1949	Apr. 4, 1949	11.6		2,600
1950	Mar. 28, 1950	13.85		4,780
1951	Apr.10,11,13-16,1951	13.1		4,020
1952	Apr.4-6, 1952	14.1		4 900
1953	Mar. 20, 1953	13.4		4,100
1954	May 3-7, 1954	10.4		1,870
1955	Oct.10-12, 1954	12.20		3,020
1956	Apr. 4, 1956	13.47		4,000
1957	June18,19, 1957	10.24		1,690
1958	Mar. 16, 1958	9.68	0.6	-
	Apr. 10, 1958	9.31		1,380
1959	Apr. 12, 1959	13.06		3,670
1960	May10,11, 1960	13 60		4,100
1961	Mar. 6, 1961	11.70	0 8	-
	Apr. 1, 1961	11.19		2,210
1962	Mar. 30, 1962	14.21		5,160
1963	Mar. 28, 1963	12 88		3,480
1964	May 9, 1964	9.63		1,430
1965	Mar. 14, 1965	12.05	0.8	-
	Sept.30, 1965	11 95		2,760
1966	Feb. 13, 1966	13.37	1.8	-
	Mar. 8, 1966	12.47		3,140
1967	Mar. 28, 1967	12.27		2,990
1968	July 4, 1968	10.74		1,970

4-0790. Wolf River at New London, Wis.

Location.--Lat 44°23'30", long 88°44'25", in SE 1/4 sec. 12, T. 22 N., R. 14 E., on right bank 100 ft downstream from Pearl Street Bridge in New London, 0.2 mile downstream from Embarrass River, and at mile 56.3.

Drainage area.--2,240 sq mi, approximately.

Gage.--Recording gage. Datum of gage is 749.0 ft above mean sea level (levels by Corps of Engineers). Prior to Oct. 4, 1951, nonrecording gage at same site and datum.

Stage-discharge relation.--Defined by current-meter measurements below 11,600 cfs.

Historical data.--The flood of April 13, 1922, was the highest since April 16, 1888, according to the New London Newspaper. The Corps of Engineers reported the gage height of the April 16, 1888, flood as 11.6 ft.

Remarks.--Daily maximums are listed prior to Oct. 4, 1951, with momentary maximums thereafter. Records for 1896 to 1913 computed by Corps of Engineers.

Peak stages and discharges

Water year	Date	Gage height (feet)	Discharge (cfs)
1888	Apr. 16, 1888	11.6	
1896	May 7-9, 1896		3,420
1897	Mar. 27, 1897		4,390
1898	Apr.1-4, 26-28, 1898		2,865
1899	May 5,6, 1899		5,430
1900	July26,27, 1900		2,750
1901	Apr. 1, 1901		6,230
1902	May 13,28, 1902		3,050
1903	Mar.26,27, 1903		5,100
1904	June 1-4, 1904		5,160
1905	Apr. 1, 1905		6,470
1906	Apr. 1-6, 1906		7,250
1907	Mar.30,31, 1907		5,100
1908	Mar.18,19, 1908		4,350
1909	May 16,17,22-24, 1909		3,420
1910	May 1-4, 1910		3,500
1911	May 25,26, 1911		3,120
1912	July29,30, 1912		9,180
1913	Mar. 19, 1913		8,170
1914	June 9,10, 1914	9.9	8,490
1915	Mar. 27, 1915	7.6	4,260
1916	Apr 4,June12,13,1916	9.7	8,960
1917	Apr. 1, 1917	9.45	8,060
1918	May 30,31, 1918	9.5	7,270
1919	Apr.14,15, 1919	8.7	6,350
1920	Mar.28,29, 1920	10.3	10,800
1921	May 3, 1921	8.8	6,560
1922	Apr. 13, 1922	11.4	15,500
1923	Apr. 24, 1923	10.2	10,100
1924	May 16-18, 1924	9.3	7,280
1925	June19,20, 1925	7.4	4,270
1926	May 1-3, 1926	7.6	4,470
1927	Mar.16-19, 1927	8.9	6,340
1928	Mar.26,27, 1928	9.5	7,810
1929	Mar.21,22, 1929	11.0	11,300
1930	Mar 18-21, 1930	5.6	2,900
1931	June25,26, 1931	4.3	2,160
1932	Apr. 15, 1932	7.4	4,260
1933	Apr. 5,6, 1933	7.9	5,320
1934	Apr. 8,9, 1934	8.4	6,000
1935	Mar.25,26, 1935	9.6	9,570
1936	Mar. 28, 1936	8.8	7,450
1937	May 1-3, 1937	8.3	6,360
1938	Mar.23-25, 1938	9.8	11,500
1939	Mar.29,30, 1939	9.8	11,100
1940	July 1,2, 1940	7.2	4,880
1941	Apr. 6-8, 1941	8.6	7,140
1942	June 5,7, 1942	9.0	7,940
1943	Apr. 2,3, 1943	9.9	11,700
1944	June 22, 1944	8.3	6,080
1945	Mar. 23, 1945	8.4	7,600
1946	Mar. 18, 1946	9.6	10,300
1947	Apr. 12,13, 1947	8.1	5,970
1948	Mar. 23,24, 1948	7.8	5,460
1949	Mar.31,Apr.1,7,9,1949	6.8	4,020
1950	Mar. 31, 1950	9.6	a 7,000
1951	Apr. 14, 1951	9.82	10,500
1952	Apr. 5, 1952	11.0	15,200
1953	Mar.26,27, 1953	9.80	10,400
1954	May 6,7, 1954	6.61	3,980
1955	Apr. 9, 1955	8.21	5,830
1956	Apr. 9, 1956	8.86	7,470
1957	Apr. 28, 1957	6.11	3,320
1958	Apr. 14, 1958	5.78	3,210
1959	Apr. 8, 1959	9.00	7,840
1960	May 12, 1960	10.52	13,300
1961	Apr. 1, 1961	8.92	7,430
1962	Apr. 2, 1962	9.26	8,490
1963	Mar. 30, 1963	9.02	7,700
1964	May 16, 1964	6.44	3,450
1965	Apr. 16, 1965	9.68	9,990
1966	Mar. 26, 1966	8.06	5,190
1967	Apr. 4, 1967	9.94	10,200
1968	July 5, 1968	8.51	6,170

a Ice affected.

4-0800. Little Wolf River at Royalton, Wis.

Location.--Lat 44°24'45", long 88°51'55", in NW 1/4 sec. 1, T. 22 N., R. 13 E., on right bank 50 ft upstream from highway bridge in Royalton and 6 miles upstream from mouth.

Drainage area.--514 sq mi.

Gage.--Recording gage. Datum of gage is 774.00 ft above mean sea level, datum of 1929. Prior to Aug. 20, 1915, nonrecording gage at datum 0.75 ft lower. Aug. 20, 1915, to Apr. 23, 1934, nonrecording gage at same datum.

Stage-discharge relation.--Defined by current-meter measurements below 4,600 cfs.

Peak stages and discharges

Water year	Date	Gage height (feet)	Ice effect (feet)	Discharge (cfs)
1914	June 7, 1914	7.6		5,470
1915	Apr. 8, 1915	3.3		1,300
1916	Mar. 30, 1916	10.0	2.8	6,000
1917	Mar. 26, 1917	8.5		4,800
1918	May 19, 1918	4.8		2,980
1919	Mar. 16, 1919	5.9	1.0	3,100
1920	Mar. 26, 1920	5.6		3,950
1921	Apr. 28, 1921	4.1		2,180
1922	Apr. 11, 1922	7.0		5,900
1923	Apr. 15, 1923	5.5		3,820
1924	Aug. 22, 1924	6.1		4,600
1925	June 15, 1925	4.1		2,180
1926	Apr. 11, Sept. 25, 1926	3.6		1,670
1927	Mar. 11, 1927	3.9		1,970
1928	Mar. 24, 1928	8.0	2.5	4,000
1929	Mar. 18, 1929	7.0		5,900
1930	Feb. 23, 1930	4.5	1.2	1,600
1931	June 22, 1931	2.3		670
1932	Apr. 9, 1932	3.1		1,250
1933	Apr. 2, 1933	4.5		2,660
1934	Apr. 4, 1934	5.2		3,500
1935	Mar. 22, 1935	7.82	2.5	3,500
1936	Mar. 25, 1936	5.00		3,420
1937	Mar. 7, 1937	4.90	0.6	2,500
1938	Mar. 19, 1938	9.50	5.5	-
	Sept. 11, 1938	5.75		4,380
1939	Mar. 25, 1939	10.33	3.0	-
	Mar. 25, 1939	10.32	2.0	6,500
1940	June 26, 1940	4.14		2,500
1941	Apr. 2, 1941	6.55	2.5	-
	Apr. 3, 1941	4.04		2,390
1942	June 1, 1942	4.47		2,810
1943	Mar. 30, 1943	8.00		6,950
1944	June 20, 1944	4.55		2,860
1945	Mar. 17, 1945	6.5		5,080
1946	Mar. 15, 1946	9.21	2.1	
	Mar. 15, 1946	8.7	1.5	5,900
1947	Apr. 7, 1947	4.6		2,860
1948	Mar. 21, 1948	7.93	1.5	5,000
1949	Mar. 22, 1949	3.21		1,480
1950	Mar. 28, 1950	11.95	4.0	6,800
1951	Apr. 9, 1951	4.61		2,860
1952	Apr. 2, 1952	7.00		5,690
1953	Mar. 23, 1953	6.28		4,840
1954	Mar. 15, 1954	2.62		1,010
1955	Oct. 3, 1954	4.67		2,890
1956	Apr. 4, 1956	8.88	4.3	
	Apr. 5, 1956	7.30		6,000
1957	Dec. 9, 1956	2.88	1.1	
	Apr. 21, 1957	2.71		1,080
1958	Sept. 6, 1958	2.81		1,150
1959	Apr. 5, 1959	9.10	3.5	4,000
1960	Mar. 31, 1960	6.00	1.7	
	May 8, 1960	5.82		4,260
1961	Mar. 28, 1961	4.13		2,890
1962	Mar. 29, 1962	3.97		2,380
1963	Mar. 26, 1963	7.78	2.6	3,700
1964	Sept. 11, 1964	2.86		1,320
1965	Apr. 13, 1965	6.03		4,680
1966	Feb. 10, 1966	5.96	2.0	2,400
1967	Mar. 28, 1967	6.35	2.0	-
	Apr. 1, 1967	5.45		4,000
1968	June 29, 1968	3.45		1,860

4-0810. Waupaca River near Waupaca, Wis
(Published as "near Weyauwega" June 28, 1916 to Oct. 18, 1917)

Location.--Lat 44°19'50", long 88°59'45", near north line of sec 1, T. 21 N., R. 12 E., on right bank 10 ft downstream from highway bridge, 4 miles upstream from Weyauwega Lake dam, 4 1/2 miles southeast of Waupaca, and about 5 miles downstream from Crystal River.

Drainage area.--272 sq mi.

Gage.--Seasonal recording gage. Altitude of gage is 760 ft (from survey level line along railroad). Prior to Oct. 19, 1917, nonrecording gage at site 1 mile downstream at different datum. Oct. 19, 1917, to Nov. 23, 1938, nonrecording gage at present site and datum. Nov. 24, 1938, to Dec. 2, 1963, recording gage at present site and datum.

Stage-discharge relation.--Defined by current-meter measurements below 2,000 cfs.

Peak stages and discharges

Water year	Date	Gage height (feet)	Ice effect (feet)	Discharge (cfs)
1917	Mar. 25, 1917	5.8		1,000
1918	Mar. 19, 1918	6.2		1,400
1919	Mar. 17, 1919	5.7		1,900
1920	Mar. 26, 1920	3.7		1,080
1921	Apr. 27, 1921	3.3		900
1922	Apr. 11, 1922	4.7		1,440
1923	Apr. 13, 1923	5.5		1,800
1924	Aug. 22, 1924	4.7		1,440
1925	July 9, 1925	3.2		784
1926	Mar. 24, 1926	5.1	1.3	1,100
1927	May 10, 1927	2.7		521
1928	Mar. 23, 1928	5.0		1,490
1929	Mar. 16, 1929	6.1		a 1,590
1930	Feb. 25, 1930	3.5		876
1931	Oct. 8, 1930	2.1		322
1932	May 7, 1932	2.55		488
1933	Apr. 2, 1933	4.9		1,490
1934	Apr. 4, 1934	5.9		2,040
1935	June 19, 1935	3.1		710
1936	Mar. 25, 1936	3.9		980
1937	Mar. 25, 1937	3.3		758
1938	Sept.10, 1938	4.7		1,440
1939	Mar. 23, 1939	5.52		1,660
1940	June 24, 1940	5.69		1,900
1941	Jan. 6, 1941	3.72	2.0	-
	Apr. 3, 1941	2.92		665
1942	Jan. 3, 1942	4.17	2.5	-
	June 7, 1942	3.49		960
1943	Mar. 26, 1943	5.00		1,570
1944	Mar. 12, 1944	3.98		1,160
1945	Mar. 14, 1945	3.76	1.2	-
	Mar. 16, 1945	3.60		1,000
1946	Mar. 7, 1946	5.70	2.0	-
	Mar. 14, 1946	4.48		1,360
1947	Dec. 4, 1946	3.76	1.5	-
	Apr. 6, 1947	3.45		855
1948	Mar. 20, 1948	6.90		2,520
1949	Dec. 9, 1948	3.50	1.5	-
	Mar. 15, 1949	3.90		652
1950	Mar. 28, 1950	8.06	2.5	-
	Mar. 28, 1950	7.92	1.9	2,100
1951	Mar. 19, 1951	3.23	1.0	-
	Apr. 8, 1951	2.96		740
1952	Apr. 2, 1952	4.67		1,440
1953	Mar. 23, 1953	5.19		1,660
1954	Mar. 14, 1954	3.08	1.0	-
	June 1, 1954	2.25		455
1955	Oct. 4, 1954	3.52		950
	Mar.12,22, 1955	4.45	1.5	-
1956	Apr. 5, 1956	5.18		1,650
1957	Apr. 21, 1957	1.96		353
1958	Apr. 6, 1958	2.02		375
1959	Apr. 1, 1959	4.92	0.7	1,250
1960	Dec. 28, 1959	4.04		1,180
1961	Mar. 27, 1961	3.78		1,070
1962	Apr. 8, 1962	2.65		620
1963	Mar. 26, 1963	5.00		1,570
1964	Dec. 12, 1963	b 3.30		-
	Sept. 4, 1964	1.87		328
1965	Mar. 8, 1965	b 6.2		-
	Apr. 12, 1965	4.51		1,360
1966	Feb. 11, 1966	6.15	2.0	1,220
1967	Mar. 30, 1967	3.74		1,060
1968	June 27, 1968	2.44		535

a Ice affected daily.
b Ice affected.

F-5

4-0830. West Branch Fond du Lac River at Fond du Lac, Wis.

Location.--Lat 43°45'45", long 88°29'00", on line between secs. 17 and 20, T. 15 N., R. 17 E., on left bank 25 ft upstream from highway bridge, 0.7 mile west of Fond du Lac and 2.5 miles upstream from confluence with East Branch.

Drainage area.--84.5 sq mi.

Gage.--Recording gage. Datum of gage is 766.78 ft above mean sea level (Corps of Engineers benchmark).

Stage-discharge relation.--Defined by current-meter measurements below 870 cfs.

Peak stages and discharges

Water year	Date	Gage height (feet)	Ice effect (feet)	Discharge (cfs)
1939	Mar. 25, 1939	3.79		602
1940	June 22, 1940	5.28		1,000
1941	Mar. 27, 1941	5.29		1,000
1942	May 31, 1942	6.16		1,320
1943	Mar. 27, 1943			a 1,390
1944	Mar. 23, 1944	2.70	1.5	-
	June 23, 1944	2.02		202
1945	June 1, 1945	4.31		686
1946	Mar. 14, 1946	5.78		1,210
1947	June 13, 1947	4.42		770

Water year	Date	Gage height (feet)	Ice effect (feet)	Discharge (cfs)
1948	Mar. 15, 1948	3.98	2.0	-
	Mar. 21, 1948	3.21		457
1949	Mar. 14, 1949	4.49	3.0	-
	Mar. 27, 1949	3.42		501
1950	Mar. 25, 1950	5.41	2.5	-
	Mar. 27, 1950	4.51		642
1951	May 3, 1951	4.28		741
1952	Mar. 21, 1952	5.60	1.5	-
	Mar. 24, 1952	4.58		894
1953	Mar. 17, 1953	5.10		1,040
1954	Apr. 24, 1954	1.12		56

a Ice affected, daily discharge.

4-0835. East Branch Fond du Lac River at Fond du Lac, Wis.

Location.--Lat 43°45'15", long 88°27'10", in sec. 22, T. 15 N., R. 17 E., on left bank at highway bridge, 0.1 mile west of U. S. Highway 41, 0.5 mile south of Fond du Lac, and 2.5 miles upstream from confluence with West Branch.

Drainage area.--77.9 sq mi.

Gage.--Recording gage. Datum of gage is 762.82 ft above mean sea level (Corps of Engineers benchmark).

Stage-discharge relation.--Defined by current-meter measurements below 1,800 cfs.

Peak stages and discharges

Water year	Date	Gage height (feet)	Ice effect (feet)	Discharge (cfs)
1939	Mar. 17, 1939	4.93	3.0	142
	Mar. 25, 1939	2.85		397
1940	June 23, 1940	5.87		2,140
1941	Mar. 23, 1941	4.96		1,090
	Mar. 26, 1941	6.13	2.5	-
1942	May 31, 1942	4.12		920
1943	Mar. 16, 1943	10.74	5.7	1,500
1944	Feb. 23, 1944	-		a 170
1945	Mar. 14, 1945	8.21	3.0	1,600
1946	Mar. 13, 1946	4.72		1,460
1947	June 13, 1947	4.65		1,220

Water year	Date	Gage height (feet)	Ice effect (feet)	Discharge (cfs)
1948	Mar. 15, 1948	5.23	0.8	1,100
1949	Mar. 6, 1949	5.85	3.5	
	Mar. 27, 1949	2.87		403
1950	Mar. 26, 1950	6.40	1.9	1,100
1951	Mar. 6, 1951	5.46	2.0	-
	Apr. 26, 1951	3.97		899
1952	Mar. 19, 1952	5.85	1.5	
	Mar. 21, 1952	4.21		964
1953	Feb. 20, 1953	5.25	2.0	-
	Mar. 15, 1953	3.70		745
1954	Feb. 16, 1954	2.30	.8	
	July 7, 1954	1.93		110

a. Ice affected, daily discharge.

4-0845. Fox River at Rapide Croche Dam, near Wrightstown, Wis.

Location.--Lat 44°19'00", long 88°11'50", in SE 1/4 sec. 4, T. 21 N., R. 19 E., at Rapide Croche Dam, 2 miles upstream from Wrightstown, and 18 miles upstream from mouth.

Drainage area.--6,150 sq mi, approximately.

Gage.--Recording headwater and tailwater gages, and since 1925, electric generation data taken each half hour are used to compute discharge records.

Remarks.--Flow regulated by storage in Lake Winnebago pool, area 263 sq mi at elevation of Menasha Dam Crest. Figures of daily discharge furnished by Corps of Engineers.

Maximum daily discharges

Water year	Date	Gage height (feet)	Discharge (cfs)
1918	May 25, 1918		16,300
1919	Apr 18, 1919		13,100
1920	Apr 10, 1920		16,600
1921	Apr. 28, 1921		14,200
1922	Apr. 23, 1922		20,100
1923	May 1-3, 1923		13,700
1924	May 13, 1924		15,500
1925	July 9, 1925		8,340
1926	June 17, 1926		9,060
1927	Mar. 30, 1927		13,300
1928	Apr. 11, 1928		15,100
1929	Apr. 4, 1929		20,600
1930	Mar. 8, 1930		6,600
1931	Dec. 2, 1930		3,100
1932	Mar. 4, 1932		9,900
1933	May 19, 1933		8,900
1934	Apr. 3, 1934		6,650
1935	Apr. 4, 6, 1935		11,100
1936	Apr. 4, 1936		6,290
1937	May 4, 1937		13,500
1938	Mar. 30, 1938		a 11,500
1939	Oct. 1, 1938		18,200
1940	June 26, 1940		17,500
1941	Apr. 20, 1941		16,600
1942	June 2, 1942		19,800
1943	June 6, 1943		21,300
1944	June 23, 1944		10,800
1945	June 6,7, 1945		15,800
1946	Mar. 27, 1946		21,300
1947	June 16, 1947		11,000
1948	Apr. 3, 1948		10,300
1949	Apr. 26, 1949		6,360
1950	Apr. 18, 1950		10,900
1951	Apr. 26, 1951		20,400
1952	Apr 18, 1952		24,000
1953	Apr. 22, 1953		12,000
1954	June 28, 1954		5,530
1955	Oct. 8, 1954		12,800
1956	May 14, 1956		10,900
1957	May 29, 1957		5,830
1958	Jan. 3, 1958		4,220
1959	May 1, 1959		11,600
1960	May 18,20, 1960		23,600
1961	Apr. 20, 1961		9,950
1962	Apr. 17, 1962		15,400
1963	Apr. 10, 1963		9,470
1964	May 26, 1964		4,070
1965	Apr. 30, 1965		12,400
1966	Mar.29-31, 1966		14,200
1967	Apr. 17, 1967		15,400
1968	June 27, 1968		12,500

a Discharge of 18,000 cfs Sept. 22, 1938, occurred as part of flood event which did not peak until Oct. 1, 1938.

4-0850.3 Apple Creek near Kaukauna, Wis.

Location.--Lat 44°19'15", long 88°17'33", on west boundary of sec. 2, T. 21 N., R. 18 E., at bridge on State Highway 55, 3 1/2 miles northeast of Kaukauna.

Drainage area.--14.6 sq mi.

Gage.--Crest-stage gage.

Stage-discharge relation.--Defined by current-meter measurements and a contracted opening measurement at 1,200 cfs.

Peak stages and discharges

Water year	Date	Gage height (feet)	Discharge (cfs)
1960	Sept.19, 1960	14.58	1,040
1961	Aug. 9, 1961	14.84	1,200
1962	Mar. 29, 1962	14.75	1,150
1963	Mar. 24, 1963	14.58	1,040
1964	May 9, 1964	13.26	340
1965	Apr. 11, 1965	13.35	380
1966	Mar. 22, 1966	14.15	770
1967	June 15, 1967	14.06	[illegible]20
1968	June 26, 1968	14.43	940

STREAMS TRIBUTARY TO LAKE MICHIGAN

04073500 Fox River at Berlin, Wis.

LOCATION.--Lat 43°57'14", long 88°57'08", in NE¼ sec.16, T.17 N., R.13 E., Green Lake County, on left bank, 0.4 mi (0.6 km) downstream from government dam, 1.0 mi (1.6 km) south of Huron Street bridge in Berlin, 2.5 mi (4.0 km) upstream from Barnes Creek, and at mi 89.0 (m 143).

DRAINAGE AREA.--1,430 mi² (3,700 km²), approximately.

PERIOD OF RECORD.--January 1898 to current year.

GAGE.--Water-stage recorder. Datum of gage is 744.52 ft (226.930 m) above mean tide at New York City (by Corps of Engineers). Prior to Oct. 27, 1954, nonrecording gage at site 0.3 mi (0.5 km) upstream at same datum.

AVERAGE DISCHARGE.--75 years, 1,089 ft³/s (30.8 m³/s), 10.34 in/yr (263 mm/yr).

EXTREMES.--Current year: Maximum discharge, 6,010 ft³/s (170 m³/s) Mar. 15, gage height, 15.59 ft (4.7[illegible] m); minimum, 644 ft³/s (18.2 m³/s) Sept. 20, 21, gage height, 8.21 ft (2.502 m).
Period of record: Maximum discharge, 6,900 ft³/s (195 m³/s) Mar. 17, 18, 1946, gage height, 15.5 ft (4.724 m); minimum observed, 248 ft³/s (7.02 m³/s) Sept. 16, 1948, gage height, 6.1 ft (1.859 m).

REMARKS.--Records good except those for October to March, which are fair. Usually less than about 5 ft³/s (0.14 m³/s) was diverted into the basin from the Wisconsin River at Portage Canal throughout the year.

REVISIONS.--WSP 1337: 1910.

Rating tables (gage height, in feet, and discharge, in cubic feet per second).
(Stage-discharge relation affected by ice Nov. 30 to Mar. 14.)

8.5	770	12.0	2,800
9.0	1,020	14.0	4,140
10.0	1,560	16.0	6,460

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2,400	2,280	1,300	1,300	1,600	1,400	3,490	3,500	3,480	1,760	680	810
2	2,400	2,340	1,200	1,300	1,600	1,400	3,460	3,720	3,410	1,700	694	780
3	2,460	2,340	1,200	1,300	1,600	1,500	3,400	3,910	3,350	1,640	702	758
4	2,460	2,340	1,200	1,200	1,600	1,600	3,370	3,970	3,280	1,610	712	766
5	2,520	2,340	1,100	1,100	1,6[illegible]	1,800	3,360	3,960	3,200	1,610	702	766
6	2,590	2,340	1,100	1,100	1,50	2,000	3,320	3,940	3,090	1,600	689	743
7	2,590	2,340	1,100	1,100	1,500	2,500	3,270	4,050	3,000	1,410	689	726
8	2,590	2,340	1,100	1,100	1,400	3,500	3,230	4,300	2,900	1,090	712	736
9	2,460	2,340	1,100	1,100	1,400	5,200	3,180	4,460	2,800	1,010	752	740
10	2,400	2,280	1,100	1,100	1,500	5,400	3,120	4,530	2,700	970	795	726
11	2,340	2,280	1,100	1,100	1,500	5,400	3,060	4,510	2,610	925	810	728
12	2,280	2,280	1,100	1,100	1,500	5,400	3,060	4,460	2,560	915	805	693
13	2,280	2,220	1,100	1,100	1,500	5,600	3,100	4,370	2,480	915	815	694
14	2,280	2,220	1,100	1,100	1,400	5,800	3,140	4,280	2,390	875	795	674
15	2,220	2,160	1,100	1,100	1,400	5,970	3,190	4,180	2,320	845	770	663
16	2,160	2,160	1,100	1,100	1,300	5,930	3,390	4,050	2,310	820	780	664
17	2,100	2,100	1,100	1,100	1,200	5,870	3,570	3,920	2,310	815	775	658
18	2,100	2,100	1,100	1,200	1,200	5,780	3,640	3,780	2,290	795	775	660
19	2,100	2,040	1,100	1,300	1,200	5,660	3,630	3,670	2,260	766	810	677
20	1,980	2,040	1,200	1,400	1,200	5,530	3,710	3,560	2,220	720	825	669
21	1,980	1,980	1,200	1,500	1,300	5,390	3,970	3,450	2,170	720	795	652
22	1,980	1,980	1,200	1,600	1,300	5,230	4,120	3,380	2,130	712	800	712
23	1,980	1,980	1,200	1,700	1,300	5,060	4,100	3,310	2,100	707	835	724
24	2,100	1,980	1,200	1,800	1,300	4,860	4,040	3,210	2,080	716	865	704
25	2,100	1,980	1,200	1,800	1,400	4,650	3,910	3,210	2,050	668	875	744
26	2,160	1,980	1,200	1,800	1,400	4,470	3,840	3,180	2,000	660	890	774
27	2,220	1,920	1,200	1,800	1,400	4,280	3,730	3,140	1,970	680	895	813
28	2,220	1,860	1,200	1,700	1,400	4,080	3,630	3,340	1,930	702	890	776
29	2,220	1,800	1,200	1,600	------	3,890	3,530	3,460	1,880	676	875	770
30	2,220	1,600	1,300	1,500	------	3,730	3,470	3,520	1,820	725	860	757
31	2,280	------	1,300	1,500	------	3,560	------	3,520	------	707	835	------
TOTAL	70,170	63,960	36,000	41,600	39,500	132,440	105,030	117,840	75,090	30,464	24,502	21,757
MEAN	2,264	2,131	1,161	1,342	1,411	4,272	3,501	3,801	2,503	983	790	725
MAX	2,590	2,340	1,300	1,800	1,600	5,970	4,120	4,530	3,480	1,760	895	813
MIN	1,980	1,600	1,100	1,100	1,200	1,400	3,060	3,140	1,820	660	680	652
CFSM	1.58	1.49	.81	.94	.99	2.99	2.45	2.66	1.75	.69	.55	.51
IN.	1.83	1.66	.94	1.08	1.03	3.45	2.73	3.07	1.95	.79	.64	.57

CAL YR 1972 TOTAL 485,629 MEAN 1,327 MAX 3,420 MIN 504 CFSM .93 IN 12.63
WTR YR 1973 TOTAL 758,333 MEAN 2,078 MAX 5,970 MIN 652 CFSM 1.45 IN 19.73

NOTE.--Once daily staff gage readings used Oct. 1 to Jan. 19.

STREAMS TRIBUTARY TO LAKE MICHIGAN

04079000 Wolf River at New London, Wis.

LOCATION.--Lat 44°23'52", long 88°44'25", in NE¼ SE¼ sec.12, T.22 N., R.14 E., Waupaca County, on right bank 100 ft (30 m) downstream from Pearl Street bridge in New London, 0.2 mi (0.3 km) downstream from Embarrass River, and at mile 56.3 (90.6 km).

DRAINAGE AREA.--2,240 mi² (5,800 km²), approximately.

PERIOD OF RECORD.--March 1896 to current year. Prior to October 1913 monthly discharges only, published in WSP 1307.

GAGE.--Water-stage recorder. Datum of gage is 749.0 ft (228.295 m) above mean sea level (levels by Corps of Engineers). Prior to October 4, 1951, nonrecording gage.

AVERAGE DISCHARGE.--77 years, 1,729 ft³/s (48.97 m³/s), 10.48 in/yr (266 mm/yr).

EXTREMES.--Current year: Maximum discharge, 14,100 ft³/s (399 m³/s) Mar. 16, gage height, 11.22 ft (3.420 m); minimum, 1,000 ft³/s (28.3 m³/s) Sept. 21, gage height, 2.10 ft (0.640 m).

Period of record: Maximum daily discharge, 15,500 ft³/s (439 m³/s) Apr. 13, 1922, gage height, 11.4 ft (3.47 m); minimum daily, 150 ft³/s (4.25 m³/s) Mar. 1, 1900.

Maximum stage known, 11.6 ft (3.54 m) Apr. 16, 1888, from information by Corps of Engineers.

REMARKS.--Records good except those for winter periods, which are fair.

Rating table (gage height, in feet, and discharge, in cubic feet per second). (Shifting-control method used Oct. 1-9, July 3 to Sept. 30; stage-discharge relation affected by ice Nov. 26-28, Dec. 1 to Mar. 11.)

Oct. 1 to Mar. 11				Mar. 12 to Sept. 30			
2.0	1,060	8.0	4,990	1.9	1,020	8.0	4,890
4.0	1,910	9.0	7,540	4.0	1,910	10.0	9,890
6.0	2,950	10.0	11,000	6.0	2,950	11.5	15,300

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3,710	2,920	1,600	1,700	2,300	1,200	4,090	4,710	8,550	2,230	1,320	1,130
2	3,850	2,890	1,600	1,700	2,200	1,200	4,000	4,940	8,760	2,140	1,310	1,130
3	3,960	2,920	1,600	1,800	2,100	1,300	3,970	5,270	8,540	2,040	1,280	1,120
4	4,030	2,900	1,600	1,800	2,000	1,400	3,960	5,590	8,010	1,940	1,250	1,170
5	4,050	3,030	1,600	1,800	2,000	1,500	3,930	6,070	7,400	1,840	1,220	1,340
6	4,000	3,050	1,700	1,800	1,900	1,800	3,900	6,750	6,770	1,740	1,170	1,480
7	4,030	3,060	1,700	1,800	1,900	2,200	4,110	7,380	6,180	1,650	1,130	1,520
8	3,930	3,070	1,700	1,800	1,800	2,800	4,250	8,010	5,640	1,550	1,120	1,510
9	3,770	3,060	1,700	1,700	1,700	5,000	4,420	8,610	5,140	1,430	1,150	1,510
10	3,500	3,050	1,700	1,600	1,700	8,000	4,490	9,030	4,700	1,380	1,270	1,500
11	3,400	3,040	1,700	1,600	1,600	11,000	4,450	9,310	4,380	1,360	1,330	1,450
12	3,260	2,990	1,700	1,500	1,600	12,600	4,420	9,390	4,220	1,350	1,310	1,340
13	3,130	2,940	1,700	1,500	1,600	13,400	4,390	9,170	4,010	1,340	1,290	1,250
14	3,000	2,880	1,600	1,400	1,500	13,700	4,370	8,710	3,820	1,350	1,280	1,210
15	2,880	2,800	1,600	1,400	1,500	14,000	4,360	8,050	3,670	1,400	1,220	1,190
16	2,750	2,720	1,600	1,400	1,400	14,100	4,590	7,390	3,550	1,440	1,210	1,160
17	2,590	2,650	1,600	1,400	1,400	14,000	4,980	6,840	3,430	1,440	1,210	1,140
18	2,440	2,580	1,600	1,400	1,300	13,700	5,330	6,290	3,320	1,400	1,280	1,130
19	2,280	2,500	1,600	1,600	1,300	13,200	5,670	5,770	3,230	1,350	1,210	1,090
20	2,090	2,410	1,600	1,900	1,300	12,500	6,240	5,240	3,130	1,290	1,270	1,040
21	1,970	2,200	1,600	2,200	1,300	11,300	7,000	4,750	3,030	1,200	1,320	1,020
22	1,910	2,150	1,600	2,500	1,200	10,100	7,370	4,390	2,930	1,170	1,380	1,110
23	2,140	2,040	1,600	2,700	1,200	8,870	7,440	4,140	2,810	1,170	1,420	1,160
24	2,520	1,920	1,600	2,800	1,200	7,850	7,260	3,940	2,750	1,190	1,400	1,200
25	2,750	1,870	1,600	2,800	1,200	7,100	6,960	3,800	2,640	1,240	1,360	1,350
26	2,900	1,800	1,600	2,700	1,200	6,400	6,610	3,850	2,560	1,290	1,320	1,340
27	2,990	1,700	1,600	2,700	1,200	5,920	6,130	3,850	2,510	1,370	1,290	1,350
28	3,050	1,700	1,600	2,600	1,200	5,110	5,660	4,410	2,450	1,420	1,270	1,370
29	3,040	1,690	1,600	2,500	------	4,630	5,210	5,330	2,380	1,430	1,270	1,400
30	3,020	1,600	1,600	2,500	------	4,390	4,800	6,610	2,310	1,400	1,220	1,380
31	2,990	------	1,600	2,400	------	4,200	------	7,780	------	1,340	1,170	------
TOTAL	96,070	76,290	50,400	61,000	43,800	234,550	154,400	195,370	132,820	45,880	39,150	38,170
MEAN	3,099	2,543	1,626	1,968	1,564	7,566	5,147	6,302	4,427	1,480	1,263	1,272
MAX	4,080	3,070	1,700	2,800	2,300	14,100	7,440	9,390	8,760	2,230	1,420	1,520
MIN	1,910	1,600	1,600	1,400	1,200	1,200	3,930	3,850	2,310	1,170	1,120	1,020
CFSM	1.38	1.14	.73	.88	.70	3.38	2.30	2.81	1.98	.66	.56	.57
IN.	1.60	1.27	.84	1.01	.73	3.90	2.56	3.24	2.21	.76	.65	.63

CAL YR 1972 TOTAL 776,849 MEAN 2,123 MAX 10,200 MIN 800 CFSM .95 IN 12.90
WTR YR 1973 TOTAL 1,167,900 MEAN 3,200 MAX 14,100 MIN 1,020 CFSM 1.43 IN 19.40

F-9

STREAMS TRIBUTARY TO LAKE MICHIGAN

04082500 Lake Winnebago at Oshkosh, Wis.

LOCATION.--Lat 44°00'41", long 88°32'01", in SW¼ sec.24, T.18 N., R.16 E., Winnebago County, in mouth of the Upper Fox River at Chicago and North Western Railway bridge, 0.2 mi (0.3 km) downstream from Main Street bridge in Oshkosh and 18 mi (29 km) south of Menasha Dam and outlet.

DRAINAGE AREA.--6,030 mi² (15,600 km²), approximately, at lake outlet at Menasha Dam.

PERIOD OF RECORD.--October 1938 to current year in reports of Geological Survey. Records from 1857 to 1938 in files of Corps of Engineers. A report on Fox River by Corps of Engineers, published as House Document No. 146, 67th Congress, 2nd session, contains semi-monthly records of inflow of Lake Winnebago for the period 1896-1917.

GAGE.--Nonrecording gage read once daily. Datum of gage is 745.05 ft (227.091 m) above mean tide at New York City (levels by Corps of Engineers). Prior to 1882, lake levels were referred to Douchman gage at Lake outlet of Menasha Dam. Datum of Douchman gage, which is still in existence, is 745.00 ft (227.076 m) above mean tide at New York City.

EXTREMES.--Current year: Maximum gage height observed, 3.92 ft (1.19 m) Mar. 25; minimum observed, 1.36 ft (0.41 m) Mar. 2, 3, 5.

Period of record: Maximum gage height observed, 5.33 ft (1.62 m) (Douchman gage) Nov. 8, 1881, minimum observed, -2.00 ft (-0.61 m) (Douchman gage) Nov. 28, 1891.

REMARKS.--Lake elevations controlled by dams at Menasha and Neenah, which are operated in the interest of navigation. Crests of both dams are at elevation 746.73 ft (227.603 m). Present limits of regulation are from 21¼ in. (540 m) above the crest of Menasha Dam to crest during navigation season, plus additional 18 in. (457 mm) below crest during winter. Oshkosh staff gage gives true level of lake, while Douchman gage readings are affected by loss of head in the channel between lake and dam.

COOPERATION.--Records furnished by Corps of Engineers.

GAGE HEIGHT, IN FEET, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2.86	2.88	2.43	2.44	2.08	1.40	3.66	3.38	3.33	3.28	2.88	2.92
2	2.91	2.86	2.46	2.43	2.08	1.36	3.60	3.48	3.32	3.16	2.82	2.86
3	2.94	2.96	2.44	2.44	2.10	1.36	3.60	3.49	3.24	3.24	2.80	2.86
4	2.90	2.90	2.42	2.43	2.07	1.37	3.57	3.50	3.26	3.22	2.80	2.90
5	2.94	2.88	2.44	2.39	2.04	1.36	3.51	3.50	3.20	3.19	2.75	2.83
6	2.91	2.86	2.40	2.36	2.04	1.40	3.47	3.46	3.20	3.10	2.67	2.90
7	2.94	2.79	2.40	2.32	2.04	1.54	3.47	3.44	3.16	3.12	2.77	2.86
8	2.96	2.88	2.43	2.31	2.02	1.63	3.42	3.48	3.16	3.10	2.94	2.82
9	2.98	2.86	2.40	2.28	1.99	1.72	3.50	3.54	3.24	3.07	2.96	2.76
10	2.98	2.82	2.43	2.25	1.96	1.82	3.18	3.44	3.14	3.14	2.88	2.78
11	3.01	2.78	2.42	2.22	1.94	2.00	3.18	3.56	3.12	3.06	2.86	2.78
12	3.00	2.76	2.46	2.20	1.92	2.24	3.18	3.56	3.26	3.02	2.85	2.84
13	2.94	2.87	2.50	2.16	1.87	2.42	3.16	3.65	3.20	2.90	2.84	2.81
14	2.92	2.71	2.47	2.10	1.68	2.66	3.16	3.63	3.20	2.84	2.83	2.82
15	2.86	2.66	2.46	2.10	1.86	2.81	3.16	3.61	3.15	2.90	2.83	2.76
16	2.82	2.64	2.47	2.09	1.80	3.00	3.20	3.62	3.16	2.84	2.80	2.71
17	2.88	2.58	2.44	2.07	1.78	3.16	3.22	3.65	2.86	2.80	2.80	2.80
18	2.88	2.56	2.45	2.08	1.75	3.28	3.28	3.67	3.25	2.74	2.78	2.78
19	2.81	2.54	2.44	2.22	1.73	3.44	3.27	3.63	3.23	2.83	2.65	2.73
20	2.78	2.52	2.44	2.24	1.69	3.56	3.31	3.56	3.20	2.94	2.96	2.75
21	2.76	2.50	2.43	2.22	1.64	3.66	3.36	3.52	3.14	2.92	2.97	2.77
22	2.98	2.47	2.38	2.26	1.60	3.74	3.36	3.52	3.17	2.83	2.94	2.64
23	2.92	2.44	2.36	2.26	1.56	3.78	3.48	3.48	3.20	2.83	2.86	2.66
24	2.92	2.45	2.34	2.24	1.52	3.84	3.54	3.44	3.10	2.79	2.81	2.67
25	2.91	2.44	2.34	2.22	1.54	3.92	3.51	3.34	3.06	2.82	2.60	2.82
26	2.91	2.36	2.32	2.20	1.50	3.86	3.49	3.33	3.22	2.81	2.47	2.84
27	2.90	2.38	2.32	2.18	1.46	3.85	3.46	3.36	3.17	2.85	2.56	2.92
28	2.90	2.38	2.30	2.16	1.42	3.82	3.43	3.38	3.28	2.76	2.54	2.92
29	2.90	2.44	2.29	2.14	------	3.78	3.48	3.36	3.28	2.76	2.51	2.94
30	2.90	2.40	2.34	2.10	------	3.75	3.46	3.36	3.30	2.76	2.71	2.91
31	2.92	------	2.44	2.08	------	3.73	------	3.28	------	2.76	2.94	------
MEAN	2.91	2.65	2.41	2.23	1.82	2.75	3.39	3.49	3.19	2.95	2.79	2.81
MAX	3.01	2.96	2.50	2.44	2.10	3.92	3.66	3.65	3.33	3.28	2.97	2.94
MIN	2.76	2.36	2.29	2.07	1.42	1.36	3.16	3.26	2.86	2.74	2.47	2.64

STREAMS TRIBUTARY TO LAKE MICHIGAN

04084500 Fox River at Rapide Croche Dam, near Wrightstown, Wis.

LOCATION.--Lat 44°19'03", long 88°11'50", in SE¼ sec.4, T.21 N., R.19 E., Outagamie County, at Rapide Croche Dam, 2.0 mi (3.2 km) upstream from Wrightstown, and 18 mi (29 km) upstream from mouth.

DRAINAGE AREA.--6,150 mi² (15,930 km²), approximately.

RECORDS AVAILABLE.--March 1896 to September 1917 (monthly discharge only), October 1917 to current year.

GAGE.--Recording headwater and tailwater gages and electric generation are read three times a day and used to compute the discharge records.

AVERAGE DISCHARGE.--77 years, 4,184 ft³/s (118.5 m³/s).

EXTREMES.--Current year: Maximum daily discharge during year, 17,000 ft³/s (481 m³/s) Mar. 29; minimum daily, 1,760 ft³/s (49.8 m³/s) July 22.

Period of record: Maximum daily discharge, 24,000 ft³/s (680 m³/s) Apr. 18, 1952; minimum daily, 138 ft³/s (3.91 m³/s) Aug. 2, 1936.

REMARKS.--Records good. Flow regulated by storage in Lake Winnebago (see p. 60). Daily discharge determined from records of flow through turbines, head, gate openings, and lockages through navigation canal. Usually less than about 5 ft³/s (0.14 m³/s) diverted into basin from Wisconsin River at Portage Canal throughout the year.

COOPERATION.--Figures of daily discharge furnished by Corps of Engineers. Records reviewed by Geological Survey.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	7,740	8,000	3,150	3,880	8,520	6,840	15,800	13,800	14,900	3,980	2,160	2,590
2	7,880	8,140	3,130	4,940	8,580	6,620	15,500	15,300	14,700	4,750	1,770	2,600
3	7,490	9,050	2,540	7,440	8,240	6,600	15,300	13,900	14,700	4,320	2,100	2,490
4	7,650	9,210	2,600	7,520	7,650	6,300	15,200	14,600	14,600	4,210	2,130	2,540
5	7,540	9,120	2,420	6,100	7,620	6,420	15,000	15,200	14,900	3,970	2,220	2,670
6	7,560	8,440	2,500	5,560	8,420	6,490	15,000	15,000	14,500	4,430	2,330	2,370
7	7,600	8,740	2,300	6,250	8,440	6,550	14,800	16,100	14,800	4,280	2,300	2,280
8	7,620	8,520	2,760	5,560	8,620	7,500	13,800	16,400	14,600	4,180	2,660	2,130
9	7,280	8,310	2,470	5,820	8,330	9,500	12,400	16,200	12,600	4,060	1,920	2,170
10	7,620	8,650	2,580	5,560	8,320	8,600	12,100	15,400	12,700	4,040	2,500	2,210
11	7,670	8,260	2,760	5,940	8,020	11,600	14,400	15,600	12,600	3,790	2,090	2,200
12	6,400	8,200	[illegible]	6,010	7,940	10,100	14,500	16,000	12,000	4,380	2,170	2,170
13	7,040	7,600	3,090	6,040	7,880	11,700	12,800	15,700	9,790	4,140	2,220	2,100
14	7,330	8,510	3,220	6,500	7,660	15,500	9,740	16,100	9,580	3,960	2,150	2,160
15	7,010	7,640	3,180	6,000	8,401	14,000	11,600	16,500	8,780	3,720	2,100	2,040
16	7,720	8,520	3,040	5,390	8,310	14,800	12,300	16,100	6,650	3,400	2,230	1,980
17	6,460	8,290	3,000	5,020	8,280	13,800	11,800	16,600	6,700	1,910	2,400	1,930
18	6,880	8,410	4,120	5,900	7,980	14,600	11,300	16,700	6,930	2,360	2,360	1,870
19	6,563	8,280	4,270	9,060	7,620	15,700	11,000	16,000	6,790	2,210	2,530	2,220
20	7,260	8,060	4,400	8,460	7,520	12,800	11,200	15,600	6,440	2,200	2,470	2,040
21	7,100	7,450	4,780	6,120	7,340	15,000	11,400	15,500	6,250	1,980	2,240	1,990
22	6,700	6,900	4,280	7,020	7,060	15,500	11,500	15,300	5,680	1,760	2,240	2,600
23	6,570	6,070	3,900	7,840	6,990	15,800	11,700	14,700	4,270	1,870	2,530	2,240
24	6,770	5,900	3,860	8,440	6,860	15,900	13,000	14,600	5,030	2,290	2,380	2,210
25	7,460	5,780	3,920	8,000	6,940	16,000	13,300	15,200	4,940	2,360	2,310	2,430
26	8,060	5,620	4,600	8,440	7,070	16,400	13,400	15,200	4,660	2,300	2,370	2,300
27	7,580	5,380	4,340	9,380	7,070	16,400	12,400	14,600	4,280	2,270	2,520	2,380
28	7,620	2,990	4,440	9,170	6,920	16,400	12,900	15,400	4,770	2,310	2,540	2,110
29	7,560	3,040	4,120	9,220	------	17,000	13,100	14,900	4,440	2,080	2,530	2,150
30	6,140	3,550	4,580	8,370	------	16,800	13,300	15,100	4,560	2,330	3,000	2,060
31	6,600	------	4,580	8,500	------	16,600	------	14,800	------	2,190	2,140	------
TOTAL	226,120	219,180	107,010	213,340	217,350	345,700	392,300	477,300	278,140	98,030	71,610	67,230
MEAN	7,294	7,306	3,452	6,884	7,763	[illegible]	13,080	15,400	9,271	3,162	2,310	2,241
MAX	8,060	9,290	4,800	9,480	8,620	17,000	15,800	16,700	14,900	4,750	3,000	2,670
MIN	6,140	2,990	2,300	3,880	6,860	6,300	9,740	13,800	4,270	1,760	1,770	1,870

CAL YR 1972 TOTAL 1,783,490 MEAN 4,873 MAX 13,200 MIN 1,360
WTR YR 1973 TOTAL 2,735,660 MEAN 7,544 MAX 17,000 MIN 1,760

GLOSSARY OF TECHNICAL TERMS

adsorption - to hold (liquid or gas) on the surface of a solid.

aerobic - living, active, or occurring only in the presence of oxygen or air.

alluvial deposit - sediment and other suspended solids deposited at the mouth of a tributary.

ammonia nitrogen - is one of the early products of microbiologic activity in the nitrogen cycle; it is considered to be chemical evidence of recent sewage contamination.

anaerobic - able to live and grow where there is no air or free oxygen.

aquatic habitat - a habitat located in water.

aquatic vegetation - plants that grow in or very near water; for this report aquatic vegetation was categorized as follows:

submergent - plants commonly found growing beneath the surface (pondweeds, coontail, algae, etc.).

floating - plants, at least portions of which float on the water's surface (lily, water shield, duckweed).

emergent - plant species growing in marshes in which there is high organic matter, nutrients, and dense algal growth.

aquifier - a water-bearing stratum of permeable rock, sand, or gravel.

artesian - referring to a well in an area having sufficient pressure to continually force water upward.

backwater - the resulting high water surface in a given stream due to a downstream obstruction or high stages in an intersecting stream.

benthic - refers to the bottom of any body of water.

benthos - those organisms that live on the bottom of a body of water.

biochemical oxygen demand - the amount of oxygen required to decompose (oxidize) a given amount of organic compounds to simple, stable substances.

biota - all the species of plants and animals occurring within a certain area or region.

bulkhead - a structure separating land and water areas, primarily designed to resist earth pressure.

chemical oxygen demand - the COD test is used to measure the organic matter content of wastewater and natural waters; a test used to measure the organic matter in industrial and municipal wastes that contain compounds that are toxic to biological life.

cold water fishery - a fish population composed of species generally requiring water temperatures of 75°F or less to survive for more than a few days (trout-cisco).

crest - top of a dam; also refers to maximum water level during a flood.

dissolved oxygen - the amount of oxygen dissolved in water; a key test in water pollution and control activities and waste treatment process control.

discharge - the quantity of flow in a stream at any given time, usually measured in cubic feet per second (cfs).

draft - the depth of water that a ship or boat draws or displaces when loaded.

dredging - the removal of bottom sediments from a stream or river to deepen a channel needed for navigational purposes.

effluent - any wastewater discharged, directly or indirectly, into waters and the runoff from land used for the disposition of wastewater or sludges, but not otherwise including land runoff.

electrofishing - a process of collecting fish through the use of the narcotic effects of electric shock generated by either AC or DC equipment.

endangered species - species that are in danger of becoming extinct.

eutrophic - a condition of a water body in which there is high organic matter, nutrients and dense algal growth.

fecal coliform - the fecal coliform test measures bacteria which are commonly found in the intestines and fecal discharges of warm-blooded animals.

flashboards - a board or boards placed at the top of the spillway of the dam to increase the water depth in the pool upstream of the dam.

flatscow - a large flat-bottomed boat with broad square ends that is used chiefly for transporting sand, gravel, or refuse.

head - height difference in water surface elevation.

head gates - gates which control water surface elevations at dams.

head race - the upstream water channel leading to the entrance of a hydropowered device.

impoundment - a body of water, usually artificially made; water that has been collected and confined as a reservoir.

interface - a surface forming a common boundary between adjacent regions.

leaching - the removal of various soluble materials from surface soil layers by the passage of water through (around) the layers.

marsh - a tract of low-lying, soft, wet land, commonly covered (sometimes seasonally) entirely or partially with water; a swamp dominated by grasses or grass-like vegetation.

microbial - referring to microscopic life such as bacteria and viruses.

navigational traffic - commercial and recreational traffic on a waterway.

outfall - (1) the vent of a river, drain, etc. (2) structure extending into a body of water for the purpose of discharging sewage, storm runoff, or cooling water.

pH - the pH scale ranges from 0 to 14 and is a measure of whether a liquid is acid, neutral or alkaline. 7.0 is neutral.

phytoplankton - minute free floating plant-like species inhabiting most water bodies.

pollutant - a residue (usually of human activity) which has an undesirable effect upon the environment; particularly of concern when in excess of the natural capacity of the environment to render it innocuous.

pool - the water contained behind a dam.

primary productivity - mg carbon/unit area/unit time; refers to the net production of biomass from organisms carrying on photosynthesis.

primary waste treatment - a primary waste treatment facility provides for sedimentation of incoming sewage prior to discharge.

recruitment - the process of adding new individuals to an existing population.

revetment - a facing of stone, concrete, etc., built to protect a scarp, embankment, or shore structure against erosion by wave action or currents.

riparian - refers to vegetative community types or land along a stream or river.

riprap - a layer, facing, or protective mount of stones randomly placed to prevent erosion, scour or sloughing of a structure or embankment; also the stone so used.

secondary waste treatment - a secondary waste treatment process involves some method for biological oxidation of organic material in the wasteflow; a secondary waste treatment facility provides this biological treatment in addition to primary treatment (common methods of secondary treatment are activated sludge, trickling filters, and lagoons).

shoal - a shallow place in a river, a sand bar or piece of rising ground forming a shallow place that is dangerous to navigation.

sluice gates - devices to regulate flow through a dam.

snagging - the act of removing large branches, logs, stumps or other organic debris from a stream.

spawning - egg laying.

succession - the replacement of one generalized vegetation type by another through time.

tail race - the discharge from mill or hydroelectric plant to a stilling pool.

terrestrial - of land, the continents, and/or dry ground; contrasted to aquatic.

thalweg - deepest point in a transverse section of a river; fluctuates based on the amount of silt in the river.

total volatile solids - measures the material which is vaporized at a rather high temperature; analysis applied to sewage sludge to measure biological stability (the solids content of a strong sewage is 275 mg/l, medium - 150 mg/l, and weak - 70 mg/l).

turbidity - turbidity is a measure of the suspended and colloidal matter in water.

warm water fishery - a fish population composed of species able to tolerate extended periods when water temperatures exceed 75°F.

wetlands - any area where the ground is too wet to raise an agricultural crop without major drainage; wetlands in this report are classified as follows:

deep marsh - water from six inches to three feet deep during growing seasons; cattails, reeds, bulrushes, spike rushes, and pond-weeds are common.

shallow marsh - water present during the growing season; cattails, river rush, spike rush, and bulrush are typical vegetative types.

fresh meadow - soggy ground, often seasonally flooded; vegetation of smartweed, grass, sedge, bur reed.

shrub swamp - water logged soil with occasional standing water; tamarack, black spruce, black ash, and elm are common trees.

winterkill - death of fish resulting from inadequate dissolved oxygen conditions under ice.

xeric - a dry condition often used to describe the moisture condition of a vegetative community type.

zooplankton - minute, free floating animal species inhabiting most water bodies.

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